3 Measuring in-hospital mortality in Australia

3.1 Current in-hospital mortality reporting in Australia

In recent years, numerous studies have been published describing mortality rates calculated for Australian deaths in hospitals for a variety of conditions and using a number of different methods. Much of this work is carried out by academics and physicians—sometimes in collaboration with government health departments. These types of activities are generally reported in the public domain within peer-reviewed journals (National and International) or as government-badged published reports. A number of examples of this type of work have been cited in the current report.

In addition to what appears in the public domain, an unknown amount of work on in-hospital mortality is effectively hidden and commonly referred to as 'grey literature'. Grey literature refers to materials that are either unpublished, or published but not in the peer reviewed literature. Such material is typically produced by governments, business or industry, and can include government reports, technical reports, white papers, or position papers.

A classic example of grey literature with high relevance to the current topic is the emergence of 'quality reports' that were produced in 2004 for every Queensland public hospital, but not available to the public. These reports came to light during the Bundaberg Hospital inquiry (Van Der Weyden 2005). Currently, the Queensland Government is regularly publishing in the public domain a number of indicators, including condition specific in-hospital mortality indicators (e.g. *Moving ahead*, *Queensland Public Hospitals Performance Report 2006–07* (Queensland Health 2007)).

To the best of our knowledge, no other jurisdiction in Australia publicly reports in-hospital mortality data in this way.

We are aware that each state and territory has developed advisory bodies that examine a variety of elements of patient safety within hospitals. Many, if not all, cover the reporting of adverse events (Wilson & Van Der Weyden, 2005), but only some of this work reaches the public domain.

The Commission may be aware that recently the Health Round Table (a privately owned, not-for-profit organisation), which is voluntarily provided with regular extracts from hospital morbidity collections by a number of Australian hospitals, has undertaken a series of analyses of in-hospital mortality using that data. It is currently feeding that data back to those hospitals. However, the methods used by that organisation are by their nature proprietary, and the outcomes not subject to any further scrutiny. The work of the Health Round Table is likely to promote further interest in this issue, both from the hospitals who subscribe to the Health Round Table, and others.

Each state and territory contributes hospital separations data to the AIHW for collation. The data elements provided by the jurisdictions are governed by National minimum data

requirements. Beyond these minimum requirements, the data items collected by each jurisdiction can range in number and complexity. For example, Victoria has been the only jurisdiction collecting data on comorbidities present on admission for several years (colloquially known as C-codes). The availability of additional data items to individual jurisdictions means that the types of variables that can be used in risk-adjustment models will vary according to each state and territory. Additionally, the types of models used to calculate in-hospital mortality may also vary.

The present review of the literature has revealed one commonly-used method for calculating in-hospital mortality. Variations in the inclusion of factors to be used for risk-adjustment have been described and the results of these variations discussed. It is likely that any recommendation for a single method of calculating in-hospital mortality will create discussion among the jurisdictions regarding whether the recommended method is as appropriate or sophisticated as the variety of methods employed to date by individual researchers, or by health departments or individual hospitals.

It is important that any method that is singled out as the basis for creating a National indicator of in-hospital mortality is replicable by individual researchers, jurisdictional health departments or individual hospitals. By basing an indicator on currently available national minimum standards governed administrative data, such as the National Hospital Morbidity Database (NHMD), the ability of the various stakeholders to validate and replicate in-hospital mortality rates is assured.

3.2 Mortality rates in Australian hospitals

The second part of this report is an analysis of Australian hospital mortality data so as to demonstrate is suitability as the basis for measuring in-hospital mortality and to show what National indicators of hospital mortality can be developed now, and in the future.

The analyses that have been undertaken have been mindful of certain considerations.

1. Although the analyses has been conducted entirely on Australian data, we recognise the importance of (a) allowing for comparisons between components of the Australian health system as a whole with other health systems, and (b) for enabling analyses to be 'rolled down' to the hospital or health-service level and 'rolled up' to state or other jurisdictions.
2. These analyses are provided by way of demonstration. The aim has been to provide the Commission with worked examples of analytic methods, scope of analyses and methods of presentation, so that the Commission can make an informed choice not only on whether to use mortality rates for reporting purposes, but, if so, how those rates might be presented.

3.3 The analytic strategy

The analytic strategy adopted was based on the outcomes of the literature review. The review made it clear that there is an emerging international consensus on best practice for national studies of hospital mortality. Those studies have the following characteristics.

- Observed in-hospital mortality rates are determined from existing nationally mandated administrative hospital morbidity data sets.

- The information contained within those data sets is used to risk adjust those rates.
- When possible, mortality is studied up to 30 days after discharge from hospital, but when linkage with births and deaths registers is not feasible, deaths during hospital stay are an acceptable end point.
- Risk adjustment is by way of logistic regression and indirect standardisation, which is used to calculate expected mortality rates.
- Those expected rates become the denominators of the ratio of observed to expected outcomes (O/E). A ratio value less than 1 is favourable and a ratio of greater than 1 unfavourable.
- When the ratio is multiplied by 100 the convention is to describe result as the HSMR (Jarman et al. 1999).
- HSMRs are presented in a variety of ways: as tables; as caterpillar plots; and, more recently, by way of funnel plots.
- Multi-level modelling has begun to be used to look at intra-hospital and inter-hospital variations in HSMR over time.

Our analyses were framed by a number of specific methodological concerns related to the implementation of the general approach described above. The most pressing were what variables to test and choose for risk-adjustment purposes? What proportion of total deaths in hospital to choose for analyses? What kind of model development process should be undertaken? How should institutional differences be taken into account? How should HSMRs be presented?

Our approach to each of these issues is outlined before a detailed presentation of the methods and results of the analyses. Our overarching strategy was as follows: having the literature review in hand and international practice identified, we came to the view that the recently released study of mortality in Canadian hospitals (CIHI 2007) was particularly relevant for our purposes.

The Canadian method is consistent with those used by the Dr Foster group in the UK and in the Dutch study (Heijink et al. 2008). Although the Canadian hospital system differs in many ways from that of the Australian system, it does not suffer the fragmentation found in the USA, and the lack of a national data system other than the Medicare patient care group. Unlike the USA, Canada has moved to using a clinical modification of the ICD-10, as has Australia. There is a nationally consistent approach to gathering morbidity data in the Canadian study that benefits from familiarity with coding in the context of diagnosis-related grouping and does not suffer from the problems with linking consultant completed episodes that can make comorbidity risk adjustment problematic using data from the British National Health Service (NHS).

The documentation of methods provided by the Canadian Institute for Health Information (CIHI) is noteworthy for its openness and comprehensiveness. The CIHI had previously been contacted by the AIHW and expressed a willingness to provide further information about their method if required, but the quality of their documentation has meant that, as yet, it has not been necessary to take them up on their offer.

Taking all that into account, we decided to base our initial model building on the example provided by the Canadian study, at least in relation to the choice of variables and confounders for testing within a regression model, and for the regression model building process. In that way, the Commission will have access to an example of HSMR creation that is broadly comparable with that used in Canadian, Dutch and

UK studies—all of which have themselves been strongly influenced by the methods developed by the Dr Foster group in the UK.

Later, we describe an exercise in which we built an Australian risk-adjustment model using a somewhat more refined process than the modelling exercise described in the Canadian study documentation. The pros and cons of using a more analytically sophisticated model, which differs from the model that is currently used most widely internationally, are discussed further in the conclusions.

3.3.1 Cross sectional and longitudinal analyses

The main body of the work is a cross-sectional analysis of one year of national data covering the period 1 July 2005 to 30 June 2006. This is based on logistic regression modelling. As noted above, we used an analytic approach closely modelled on current Canadian practice, which is similar to methods used in UK and Dutch work.

As discussed in the literature review, longitudinal studies are emerging as a valuable way to assess data, as well as for investigating the presence of trends in mortality outcomes. We used a two-stage method similar to Heijink et al. (2008), in which logistic regression modelling (as above) is followed by multi-level modelling.

3.3.2 Observed mortality

Observed mortality was confined to deaths in hospitals. Had data been available for this project which included deaths during the 30 days post-discharge, then they would have been used as well. While the availability of such data would have been preferable, our assessment of the literature led us to conclude that it was safe to proceed with an analysis of in-hospital mortality alone (see Section 2.4.2).

3.3.3 Choice of variables for risk adjustment of expected mortality rates

The variables tested for the purposes of risk adjustment were all derived from the hospital data set that were provided by the AIHW. The study of the Canadian data, and the existing literature, made it clear that the variables to be included needed to cover principal and secondary diagnoses, demographic information, modes of admission and length of hospital stay. A small number of exclusion criteria were applied, including admissions for palliative care, neonates (there are considerable difficulties in Australia with issues around coding of qualified and unqualified new-born babies, which makes the identification of denominators problematic) and patients who discharged themselves against medical advice and so did not complete the hospital care judged necessary by their treating doctors. We also tested the value of adding a measure of social deprivation (see *Appendix 5 Data issues* for information on how socioeconomic indicators for areas (SEIFAs) were derived) related to the usual place of residence of patients, but did not include it in our final model (see below). We found that the addition of a SEIFA measure did not materially add to the discriminatory power of our risk-adjustment model, and it makes international comparisons problematic, because social deprivation is measured quite differently in different countries.

3.3.4 What proportion of total deaths in hospital should be chosen for analysis?

The majority of international studies of hospital mortality have been confined to a subset of all primary hospital diagnoses. The underlying rationales for choosing high-risk groups of one kind or another have been discussed in the literature review. However, the recent trend in the international literature has been to confine analyses to the diagnoses assigned most often to cases ending with death in hospital and which account for 80% of in-hospital deaths in the population of interest. We followed that practice. We found that 68 three-character Principal Diagnosis ICD-10 codes accounted for 80% of in-hospital deaths in the 2005–06 NMDS data set (see *Appendix 1*). About one-fifth of records had one of these 68 Principal Diagnosis codes.

We also analysed the complement of the first group—that is, cases with any Principal Diagnosis code except the 68 that were most frequently present in records of in-hospital deaths. By definition, this second group includes 20% of in-hospital deaths. It comprises about four-fifths of all records. Because of the large number of principal diagnoses involved, this required a somewhat different approach to risk-adjustment modelling, which is described in Section 4.5.2. The method presented there is a novel contribution to the analysis of in-hospital mortality, and may be of interest to others.

Thirdly, we analysed the whole set of data meeting the study criteria. This is the sum of the first and second sets. By definition, it includes all records and all deaths.

3.3.5 What kind of model development process should be undertaken?

Most of our analyses were undertaken after a risk-adjustment-model building process, in which we followed the strategy adopted for the Canadian study (CIHI 2007). We refer to this as the risk-adjusted Canadian referred mortality model (RACM) and model parameters are presented for that model.

We also undertook another model-building process that includes a more sophisticated approach to variable preparation and inter-action analysis in the logistic regression model. We refer to that model as the elaborated risk-adjusted mortality model (ERM). The ERM model is described fully and some comparisons with the RACM model are included in Sections 4.8 and 5.8. Although the ERM model has performance advantages, we have opted to use the RACM model for the main part of the report, because it is relatively well-established in the literature. The Commission may wish to consider how the ERM model might be used. A comprehensive analysis using the ERM model has not been undertaken, though it would be straightforward to complete such an analysis if required.

3.3.6 How should institutional differences be taken into account?

The importance of making inter-hospital comparisons only within groups of like hospitals was emphasised in the literature review. There is a well-established peer grouping process for Australian public hospitals, supported by the Commonwealth, and based on a hospital peer group classification developed by the AIHW. Although originally peer grouping was simply by reference to volumes of activity, the process has been somewhat refined, and is described as follows (DoHA 2007: 1)

'Although not specifically designed for purposes other than the cost per casemix-adjusted separation analysis, the peer group classification is recognised as a useful way to consistently categorise hospitals for other purposes, including presentation of other data.'

The AIHW national peer group classifications are determined using several criteria:

- size of hospital determined by number of acute casemix weighted separations and actual separations
- demographic characteristics of major patient groups; e.g. women and children, Aboriginal and Torres Strait Islander status
- teaching and research status
- proportions of acute, rehabilitation, palliative care and non-acute patients treated.

The inclusion criteria and code numbers for these peer groups are shown in Table 2.

Although the model building exercise made use of all available Australian hospital separations, hospital level results for public hospitals are displayed within peer groups, as described above.

Equivalent grouping was not available for private hospitals. Indeed, many private hospitals are not separately identified in the NHMD. Hence, analysis of private hospitals was not undertaken in this project.

3.3.7 How should HSMRs be presented?

The HSMRs produced by our analysis are presented as tables, caterpillar plots and funnel plots.

3.3.8 Confidentiality

Due to the sensitive nature of the work undertaken for this project, we have taken two steps in order to secure the confidentiality of individual institutions:

1. Establishment identifiers have been replaced with study-assigned identification codes.
2. The HSMR values present in the results section for the single-year analysis have been adjusted using a recalibration process in order to mask their true value. The recalibration relates to the process of identifying deaths in all patients receiving palliative care. The effect is to produce values that serve the purpose of demonstrating the operation and performance of the methods, and the distributions of HSMRs, but provides institution-specific HSMR values that differ somewhat from the values that would be obtained when applying the methods without recalibration.

These two steps have the effect of masking individual institutions and preventing other parties from attempting to apply the model to their own institutional data in order to try to compare themselves with other institutional HSMRs present in the report or presented elsewhere. The recalibration was applied only to the production of the HSMR values for the single-year analysis. All other analyses (e.g. discriminatory and explanatory power, goodness of fit) were carried out on unmasked data. Details of the recalibration can be made available on request.

We recognise that individual HSMRs will be of high interest to institutions and other interested parties. However, at this stage of the process, it is important that the focus remains on the method and means of presentation rather than the actual HSMR values. As mentioned previously, a number of institutions who are members of the Health Round Table, are currently in possession of hospital mortality data for their own and other hospitals. The recalibration of HSMR values here means that comparison with results provided by bodies such as the Health Round Table will not allow confident identification of particular institutions.