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Constructing Error Bands for Mortality Rates using Simulation

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Analytical Services Branch

Methodology Advisory Committee

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INQUIRIES

The ABS welcomes comments on the research presented in this paper.
For further information, please contact Dr Phillip Gould, Analytical Services Branch on Canberra (02) 6252 5315 or email <analytical.services@abs.gov.au>.

CONSTRUCTING ERROR BANDS FOR MORTALITY RATES USING SIMULATION

Sean Buttsworth
Analytical Services Branch

QUESTIONS FOR THE COMMITTEE

1. Is the simulation approach described in this paper a useful direction to be heading?
2. Is our application of simulation methods technically adequate?
3. Are there alternative methods that may be more appropriate?
4. Is the assumption of perfect temporal correlations for adjustment factors useful?
5. Does the MAC panel have any other thoughts about the calculation and use of bias correction factors for Indigenous mortality?

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CONSTRUCTING ERROR BANDS FOR MORTALITY RATES USING SIMULATION

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ABSTRACT

Indigenous mortality estimates are a key input informing the National Indigenous Reform Agreement (NIRA). Estimates of the mortality rates include many sources of error. However the current standard methods used for deriving confidence intervals, and for associated hypothesis testing, consider only the death counts to have variability. This has raised concerns about their adequacy and whether the conclusions drawn from these intervals may be misleading . A simulation approach has been investigated by the ABS to better capture the multiple sources of uncertainty in the rates. Comparison of this simulation method to the standard method found that while the simulation method led to significantly larger intervals in general, in most situations of interest the conclusions drawn about statistical significance were largely unchanged.

1. BACKGROUND

In March 2008 the Australian Government made a formal commitment, entitled 'Closing the Gap,' to pursue Indigenous health equality. The Council of Australian Governments (COAG) has set specific timeframes and targets in six key areas – Indigenous life expectancy, child mortality, early childhood development, numeracy and literacy, educational attainment and employment.

The COAG reform council is responsible for overseeing progress towards these goals and has 'the task of assessing and publically reporting the performance of governments towards these commitments.'

The National Indigenous Reform Agreement (NIRA) is the policy framework for 'Closing the Gap' in Indigenous disadvantage, focussing on the six key areas mentioned above. The two areas of relevance to the work described in this paper are Indigenous life expectancy and infant mortality. The targets documented in the NIRA for these areas are:

- close the life expectancy gap within one generation, and
- halve the gap in mortality rates for Indigenous children under five within a decade.

A number of performance indicators have been established in order to monitor progress in each of the six key areas. Mortality rates are a key indicator for the areas of life expectancy and child mortality.

Starting with a baseline report for 2008–09 (published in 2010) a NIRA performance report will be published annually. The ABS provides the suite of mortality estimates required for NIRA reporting, drawing from its Cause of Death Collection and Death Registration Collection. The ABS has undertaken not only to provide the mortality rates, but also to provide confidence intervals for these rates. Confidence intervals for the difference of two rates (e.g. Indigenous and non-Indigenous) will provide a test of statistical significance. Comparisons of interest include differences between Indigenous and non-Indigenous rates, differences between states, and differences over time.

Confidence intervals for some performance indicators, including mortality rates, have already been supplied for the NIRA by other public service agencies. These are simple Wald intervals assuming that only the death count has variability. The ABS had concerns that these 'standard' confidence intervals may not adequately capture all sources of error in the mortality rates, which may include:

- natural variability in the death counts,
- sampling error in the estimated resident population (ERP) counts,
- natural variability in ERP over time due to births, deaths and net migration, and
- bias due to misreporting of Indigenous deaths.

Intervals that do not take account of these various error sources will be potentially misleading to the users. For this reason the ABS did not supply confidence intervals for mortality rates for the 2008–09 NIRA baseline report. Instead, work was commenced to investigate alternative methods for deriving confidence intervals for mortality estimates provided for the NIRA.

This paper describes and recommends a simulation approach for providing measures of the reliability of mortality rates. An application of simulation methods has already been implemented by the ABS for deriving confidence intervals for Indigenous life expectancy (ABS, 2009).We present results comparing the simulation method to the standard method, comparing the size and location of the intervals using both methods. Also examined was the extent of differences in outcomes for the key tests of statistical significance.

2. DATA REQUIREMENT AND DATA SOURCES

2.1 Data requirements

This section describes the various types of mortality estimates required by the National Indigenous Reform Agreement. Greater detail may be found in Appendix A.

One of the challenges of quantifying error in the mortality rates is the range of estimates that are of interest. There are a few dimensions to this:

1. the type of estimates required,
2. the level of estimates required, and
3. the comparisons required.

1. The type of estimates required

These include:

- crude mortality rates – a ratio of an observed death count and population count expressed per 100,000 population;
- child mortality rates are crude death rates for children aged 0–4 expressed per 100,000 population;
- infant mortality rates are the ratio of death counts for children under one year to the number of live births in that year expressed per 1000 live births; and
- age standardised mortality rates (see Box 2.1) expressed per 100,000 population.

These estimates are measured by various classifications of cause of death. Where there are small numbers of deaths in a classification then aggregation over a number of years (e.g. 2004–2008) occurs for both the death count and population counts.

2. The level of estimates required

Mortality estimates are produced by gender at jurisdiction and national levels. The jurisdictions are the states New South Wales, Queensland, South Australia, Western Australia and the Northern Territory. For Victoria, Tasmania and the Australian Capital Territory, the misreporting rates for Indigenous deaths have been considered too high for the data to be published. The national totals generally exclude Victoria, Tasmania and the Australian Capital Territory.

BOX 2.1 AGE-STANDARDISATION

Age standardisation is a crude method used to mitigate the confounding effects of age when comparing two populations. It is used when the variables compared are related to age and the populations have distinctly different age structures. All age-standardised estimates for NIRA are derived using the direct method. In the NIRA context the age-standardised estimates are given by the formula below:

$$\hat{r}_{as,j} = \sum_i w_i \hat{r}_{i,j}$$

where

$\hat{r}_{as,j}$ is the directly age-standardised estimate for population j (Indigenous or non-Indigenous);

w_i is the proportion of the population in age group i in the population to which we are standardising (2001 Estimated Resident Population);

$\hat{r}_{i,i}$ is the mortality rate for age group i in population j.

3. The comparisons required

The main comparisons of interest may be grouped into the following types:

- TYPE 1 – INDIGENOUS/NON-INDIGENOUS GAP: The gap between Indigenous and non-Indigenous estimates at a single time point (including aggregation over years). These may be crude rates or age-standardised rates. The measure of this gap is either a rate ratio or a rate difference.
- TYPE 2 – CHANGE IN INDIGENOUS/NON-INDIGENOUS GAP: The change in the Indigenous/non-Indigenous gap over time. Again, this may be for crude rates or age-standardised rates.
- TYPE 3 – JURISDICTIONAL: The differences between jurisdictions. Of particular interest are differences between the Indigenous crude mortality rates for jurisdictions. Also of key interest are the differences among jurisdiction age-standardised mortality gaps.
- TYPE 4 – CHANGE IN INDIGENOUS RATES: The change in Indigenous crude rates over time.

For each of these comparisons we wish to conclude whether the observed differences (or ratios) are statistically significant. We do this by constructing $100(1-\alpha)\%$ intervals for the difference estimates and declaring significance if the observed difference is outside this interval.

2.2 Data sources

As mentioned in Section 1 mortality rates are subject to multiple sources of variability and error. Before we determine an estimation method it will be helpful to define the population measure that we seek to estimate – that is, the true, unknown underlying quantity. Having defined this population measure (in terms of its components) we then describe and discuss the data sources available for estimating it via its multiple components.

Without loss of generality we choose the simple case of an Indigenous crude rate:

$$\rho = \frac{\lambda_D / \mu_C}{\mu_N}$$

where:

λ_D is the unknown underlying death count inclusive of misreporting errors,

μ_N is the true population count, and

μ_C is the identification rate – the true rate of correctly reported Indigenous deaths.

We note that the raw death count λ_D is being adjusted for the misreporting of Indigenous deaths by dividing by μ_C. From now on we will refer to μ_C as the Indigenous misreporting adjustment factor or, more briefly, as the adjustment factor. Estimates of λ_D, μ_N and μ_C are available as described below.

Population count

The true population count μ_N is approximated by the estimated resident population (ERP) count. The (simplified) process of deriving ERP is briefly:

- A base level ERP is obtained by taking raw counts in the census year and adjusting upward to compensate for undercount. Estimates of undercount adjustment factors are obtained from the Post Enumeration Survey (PES) which is a national sample of around 80,000 persons.
- For the Indigenous population in the 2006 census year, an Empirical Bayes technique was applied to smooth the initial undercount factors. This was done to produce more stable population estimates.
- In post-censal years the non-Indigenous population is updated based on recorded births, deaths and net migration. Because reliable birth, death and internal migration data does not exist for the Indigenous population, post-censal Indigenous estimates are projections based on assumptions about fertility and other relevant factors.

Further details may be found in the Information Paper ABS(2009b).

Sampling error in the ERP is induced because raw counts are adjusted to the PES sample estimates. The sampling error in the 2006 ERP has already been quantified by the ABS (at fine levels of age group, sex and state) in previous work conducted to produce life expectancy estimates. In essence, this has been achieved by generating simulated PES estimates using the PES standard errors and assuming Normality of the PES estimators. The steps required to derive the base level ERP are repeated for each set of simulated values. The variation in the resulting simulated ERP values gives the estimated sampling error in the base level ERP. See Gross and Khoo (2009) for more detail.

The ERP in post-censal years will have additional variation due to births, deaths and migration. This needs to be modelled, which is described in Section 4.2.

Death count

Deaths are recorded in the state Registrees of Births, Deaths and Marriages which are then provided to the ABS for coding and compilation into aggregate statistics. Deaths are for the year of registration, which can be different to the year of death, which is due to lags in the reporting and compiling of deaths. For example 94.8% of deaths registered in 2009 also occurred in that year. Further details may be found in the publication "Deaths, Australia" (ABS, 2011).

The observed death count for a year of registration will include errors due to misreporting of Indigenous status. The parameter λ_D denotes the true death count inclusive of misreporting errors. The observed death count is considered an estimate of this true unknown value where the observed counts are generated from a random process. This is described in Section 4.2.

Indigenous misreporting adjustment factor

A known problem with death counts is misreporting of Indigenous status, which has its greatest effect on the estimated Indigenous population. The evidence suggests that the great majority of Indigenous deaths are recorded, but that a proportion will be wrongly classified as non-Indigenous.

Work was carried out by the ABS in 2008 to examine the extent of the Indigenous death misreporting problem. Adjustment factors denoted by μ_C ,were derived to estimate the true rate of misreporting. These were calculated as inputs into Indigenous life expectancy estimates. In summary, the adjustment process was:

- Registered deaths from 2006–07 were probabilistically linked to the 2006 Census using name, personal characteristics and geographical information.
- The expected number of Indigenous deaths in the Census linked data was calculated based on the PES.
- The ratio of the observed number of Indigenous deaths in the Census linked file to the expected number of Indigenous deaths based on PES gave the estimate of the rate of correctly reported Indigenous deaths. This is the estimated adjustment factor.

Estimates of adjustment factors are available for New South Wales, Queensland, Western Australia, the Northern Territory and Australia. As for the ERP these estimates have sampling error due to the sampling error in the PES. Estimates of their sampling error have also been produced in a similar way as for the ERP estimates of sampling error. Further details are given in Gross and Khoo (2009).

The extent of Indigenous misreporting will vary over time. Thus there will be some additional variation in the estimated reporting rates additional to sampling error. This is discussed in Section 4.2.

The estimates of correctly reported Indigenous death rates are given table 2.1 below. These may be found in the publication "Experimental Life Tables for Aboriginal and Torres Strait Islander Australians" (ABS, 2009a).

2.1 Estimates of correctly reported Indigenous death rates

State / Territory	*Identification rate*
New South Wales	0.87
Queensland	0.94
Western Australia	1.11
Northern Territory	1.09
Victoria / South Australia/ Tasmania / Aust. Capital Territory / Other Territories combined	0.65
Australia	0.92

3. INTERVAL ESTIMATION FOR POISSON RATES

In this section we give a brief review of the literature on confidence intervals for count data. We also give a justification for choosing a simulation approach in our situation.

3.1 The standard approach

To estimate natural variation in mortality counts the typical approach is to assume a Poisson model, since deaths may be considered a rare event generated from a large population. If we use d_t to refer to the observed death count aggregated over a period of time t, then d_t is taken to be a realisation of the random variable $D_t \sim \text{Pois}(\lambda_t = d_t)$. For a (crude) mortality rate d_t/n_t, where the population n_t is considered constant, the simplest form of confidence interval is the Wald, with a $100(1-\alpha)\%$ interval for λ_t/n_t given by:

$$\frac{d_t}{n_t} \pm z_{(1-\alpha/2)}\left(\frac{d_t/n_t}{\sqrt{d_t}}\right)$$

For a difference of *independent* rates the Wald confidence interval is:

$$\frac{d_{1t}}{n_{1t}} - \frac{d_{2t}}{n_{2t}} \pm z_{(1-\alpha/2)}\sqrt{\frac{\left(d_{1t}/n_{1t}\right)^2 + \left(d_{2t}/n_{2t}\right)^2}{d_{1t}+d_{2t}}}$$

and this interval may be used for a $100(1-\alpha)\%$ test of the statistical significance of the rate difference. Similar Wald intervals apply for age-standardised rates and rate differences. This is the 'standard' methodology currently used for the NIRA reporting framework (see appendix A for further details).

The Wald interval uses a Normal approximation for d_t/n_t which is suitable when the number of deaths is large. The U.S. National Center for Health Statistics, NCHS (2010), suggest that more than 100 deaths is a reasonable point at which to apply the normal approximation. For small death counts (or Poisson-modelled counts in general) the performance of the Wald interval is known to be poor due to the asymmetry of the count distribution/s. This has prompted a number of alternative methods for deriving confidence intervals for rates and rate differences.

For a single (crude) Poisson rate based on a small death count, a number of methods are available and their performance has been evaluated by various authors (Li *et al.*, 2011). These methods include

- the first Normal with continuity correction,
- the Rao score interval,
- the Freeman and Tukey interval,
- Jeffrey's interval,
- Byar's approximation and
- the Gamma method.

Byar's approximation is described by Breslow and Day (1987) and is recommended (for example) by the U.K. Association of Public Health Observatories, APHO (2008). The Gamma method is described by Fay and Feuer (*Statistics in Medicine*, 1997) and is adopted by the U.S. National Center for Health Statistics in their National Vital Statistics Reports. The Gamma method may be adjusted to include intervals for the case of age-standardised rates. The method by Dobson *et al*. (1991) may also be used to calculate a confidence interval for a single age-standardised rate.

The construction of a confidence interval for the difference of Poisson rates enables us to compare two rates to see if their difference is statistically significant. A conservative, and somewhat unsatisfactory, alternative is to compare the intervals of the single rates. This method has been used by the APHO and the by the U.S. National Center for Health Statistics for significance comparisons where death counts are small. Of course, this method only allows one to claim α % significance when confidence bands do not overlap, without firm conclusions when they do.

Direct approximations for the confidence interval of a difference (or linear function more generally) of independent Poisson rates have also been proposed. These include the Bayes interval using non-informative priors and the t interval with Scattertwaite's degrees of freedom. These are examined by Stamey and Hamilton (2006).

An interesting approach taken by Zou and Donner (2008) is to derive a confidence interval for a linear function of parameters from each of the single parameter intervals. The technique, known as the Method of Variance Estimates Recovery (MOVER) was examined by Li *et al.* (2011) for the case of a difference of Poisson rates. When combined with superior small-count methods for a single rate, the MOVER intervals were found by Li *et al.* to outperform the direct approximation methods mentioned above.

A generalisation of the MOVER method was proposed by Newcombe (2010). The method of propagating imprecision (PropImp) is similar to MOVER in that it constructs a confidence interval for a function of k independent parameters $f(X^1,\ldots,X^k)$ from the single confidence intervals for $X^1,\ldots,X^k$. The method extends on MOVER by allowing the function f to be non-linear, but requiring f to be monotonic over the working range of it's parameters. More precisely (and adopting Newcombe's notation):

Let (L_z^i, U_z^i) be a $1-2Q(z)$ confidence interval for X^i where $Q(z)$ is the standard Normal tail function. Then, for f an increasing function of all its parameters, a $1-2Q(z)$ CI for $f(X^1,\ldots,X^k)$ is given by:

Lower limit: $$L = \min_{\{z_i\}:\Sigma z_i^2 = z^2} f\left(L_{z_1}^1,\ldots,L_{z_k}^k\right)$$

Upper limit: $$U = \max_{\{z_i\}:\Sigma z_i^2 = z^2} f\left(U_{z_1}^1,\ldots,U_{z_k}^k\right)$$

For any parameter X^i that is a decreasing function of f then $L_{z_i}^i$ and $U_{z_i}^i$ are interchanged. We note that to find the set of z_i values to minimise $f(L_{z_1}^1,\ldots,L_{z_k}^k)$ or to maximise $f(U_{z_1}^1,\ldots,U_{z_k}^k)$ requires a computational algorithm.

3.2 The simulation approach

The PropImp method may be suitable for the case of a function f of non-linear independent parameters that are monotonic in f. A more general and flexible solution is provided by computer-intensive methods such as bootstrapping or Monte Carlo simulation, as Newcombe himself notes (Newcombe, 2010, page 3155). Simulation methods are particularly useful for complex functions of parameters where the joint probability density function is difficult or impossible to determine analytically. Monte Carlo (i.e. stochastic) simulation is usually married with Bayesian inference. A key advantage of this approach is the ability to incorporate bias (from say misreporting or under-reporting) via prior distributions. An example of this approach includes that given by Greenland (2004). Of even more relevance is the work done by Greer, Stamey and Young (2011) where Bayesian credible intervals are derived for the difference of independent Poisson rates which are subject to under-reporting.

Ideally an interval estimate for a mortality rate will capture the variability in the death counts and ERP counts, together with the bias and uncertainty resulting from misreporting of Indigenous deaths. It would also be desirable for the interval estimate to have good performance (boundary-preserving properties) when the death counts are small.

Clearly, when our mortality rates include an estimate of the Indigenous adjustment factor, an estimate of the population total and an estimate of the death count, they are a complex (i.e. non-linear) function of random variables. Not only this we also have that the measure is based on multiple collections with their own sources of error, and that error arises from sources other than random sampling. Of the methods described in Section 3.1 only PropImp may potentially be suitable. However it is not clear that PropImp could be applied to mortality, in particular to the highly complex case of age-standardised Indigenous estimates.

Simulation methods enable the complexity in the mortality rates (including age-standardised rates) to be captured without having to derive what may well be intractable analytical formulas, or make large approximations. That is why simulation methods have been chosen for this investigation.

4. DESCRIPTION AND APPLICATION OF THE SIMULATION METHOD

4.1 Outline of method

The population parameter of interest is given by

$$\rho = \frac{\lambda_D / \mu_C}{\mu_N},$$

where:

ρ is the true mortality rate (unknown),

λ_D is the underlying death count inclusive of misreporting errors (unknown),

μ_C is the identification rate – the true rate of correctly reported Indigenous deaths (unknown), and

μ_N is the true population count (unknown).

Our estimator of ρ is denoted by T with

$$T = \frac{D/C}{N},$$

where:

D is the estimator of λ_D with realised (sample/observed) value denoted by d,

N is the estimator of μ_N with realised (sample/observed) value denoted by n,

C is the estimator of μ_C with realised (sample/observed) value denoted by c,

and D, N and C are assumed independent.

We assume plausible distributions for D, C and N, namely:

$$D \sim \text{Poisson}\left(\lambda_D\right),$$
$$N \sim \text{Normal}\left(\mu_N, \sigma_N^2\right) \text{and}$$
$$C \sim \text{Normal}\left(\mu_C, \sigma_C^2\right).$$

We have a realised value of T denoted by $t = \frac{d/c}{n}$.

We wish to form a confidence interval for θ. This requires the probability distribution of T, which is expected to be complicated, and so we estimate it using a parametric bootstrap. That is, we independently simulate R times from each of the models listed above, with the unknown model parameters replaced by their estimates n, $\hat{\sigma}_N^2$, c, $\hat{\sigma}_C^2$ and d (the observed death count). To be explicit, we simulate values (denoted with a *) from the following fitted models:

$$\begin{aligned} D_1^*, \ldots, D_R^* &\quad \text{from Poisson}(d) \\ N_1^*, \ldots, N_R^* &\quad \text{from Normal}\left(n, \hat{\sigma}_N^2\right) \\ C_1^*, \ldots, C_R^* &\quad \text{from Normal}\left(c, \hat{\sigma}_C^2\right) \end{aligned}$$

These input simulated values are combined to give simulated estimates $T_1^*, \ldots, T_R^*$. The distribution of our estimator T is approximated by the bootstrap distribution of T^*. The value of R was 1000.

For simplicity, bootstrap percentile intervals have been used. That is, we construct an error band by taking the 2.5-th and 97.5-th percentiles. This method is a suitable choice if the estimator T is unbiased and symmetric. This may be checked by examining the bootstrap distribution of T^* for skewness and the bootstrap estimate of bias given by $\overline{T}^* - t$.

Error bands for age-standardised estimates are formed in a similar way. An interval for the difference of rates may be simply constructed by using the simulated rate differences.

4.2 Derivation of and justification for estimators

Death count

The observed death count d is considered to be a realisation of the random variable D where $D \sim \text{Poisson}\left(\lambda_D\right)$. This is a typical assumption made when quantifying the variation in mortality data. This model is justified on the grounds that the Poisson distribution closely approximates the Binomial when the population is large and the probability of an event is very small. As well, deaths are considered to be independent events. Convenient properties of the Poisson distribution are that the variance is equal to the expected value and that a sum of independent Poisson random variables with parameters $\lambda_1, \ldots, \lambda_k$ is itself a Poisson variable with parameter $\Sigma \lambda_i$. This second property is useful when summing over age groups or over a number of years.

Estimated Resident Population

As described in Section 2.2 estimated resident population (ERP) counts have variability associated with them. This is due to both sampling error and natural variation from updates in births, deaths and migration.

Estimation of the sampling error in the ERP estimator N has been outlined in Section 2.2. A Normal approximation for N is justified by noting the large sample size of the PES and invoking the central limit theorem for finite populations.

Outside of Census years ERP counts (for non-Indigenous) are based on updating the Census with recorded births, deaths and estimated net migration. Thus we expect there to be strong (but not perfect) correlations between 2006 ERP counts and other ERP estimates. This dependence structure was modelled crudely by deriving ERP estimates in years pre and post 2006 from the simulated 2006 ERP estimates. A one-year-apart growth factor θ_t was simulated independently for each year t (its realisation denoted by $\theta_{g,t}$) and applied such that:

$$\theta_t \sim \text{Normal}\left(\mu_{\theta,t}, \sigma^2_{\theta,t}\right)$$

$$\begin{aligned} n_{g,t} &= \theta_{g,t}\, n_{g,t-1} \quad \text{for } t \text{ after 2006 with} \quad \mu_{\theta,t} = n_t / n_{t-1} \\ n_{g,t-1} &= \theta_{g,t}\, n_{g,t} \quad \text{for } t \text{ before 2006 with} \quad \mu_{\theta,t} = n_{t-1} / n_t \end{aligned}$$

Estimates of σ^2_θ were obtained by taking the sample variance of a number of non-Indigenous observed year-apart growth rates at the age group by sex level and at the state level. Note that for the Indigenous population ERP counts outside of Census years are projections , rather than updates using births, deaths and migrations records. Therefore we apply the year-apart growth rate variance estimates from the non-Indigenous population to the Indigenous. That is, we assume the variability in Indigenous year-apart growth rates will be the same as for the non-Indigenous.

Estimating natural ERP variability in the way described above is similar to simulating from a multivariate normal distribution[1] for a vector of yearly populations estimates.

Here we have:

$$\bar{\mu}_n = \begin{bmatrix} \mu_{04} \\ \mu_{05} \\ \mu_{06} \\ \mu_{07} \\ \mu_{08} \\ \mu_{09} \end{bmatrix} \quad \text{with} \quad E\left(\bar{\mu}_n\right) = \begin{bmatrix} n_{04} \\ n_{05} \\ n_{06} \\ n_{07} \\ n_{08} \\ n_{09} \end{bmatrix} \quad \text{and} \quad Var\left(\bar{\mu}_n\right) = \begin{bmatrix} Var\left(\theta_{04}\theta_{05}\mu_{06}\right) \\ Var\left(\theta_{05}\mu_{06}\right) \\ Var\left(\mu_{06}\right) \\ Var\left(\theta_{07}\mu_{06}\right) \\ Var\left(\theta_{08}\theta_{07}\mu_{06}\right) \\ Var\left(\theta_{09}\theta_{08}\theta_{07}\mu_{06}\right) \end{bmatrix}$$

and implicit correlations between the ERP yearly estimates.

1 Not quite multivariate normal because years apart from 2006 are derived as a product of Normal distributions.

When applied correctly the described method of modelling ERP appears to accurately reproduce the observed correlations at the different lags. Because of a coding error the actual correlations were slightly over-estimated. However, the observed correlations in ERP data are very high with correlation coefficients of greater than 98% even after 5 years. Thus we expect the extra variation in the ERP estimates due to modelling natural variability to be very small relative to the sampling error.

Indigenous misreporting factor

The simulation method includes an estimated adjustment for bias in Indigenous deaths due to misreporting. Estimation of the sampling error in this estimator C has has been outlined in Section 2.2. As for the ERP estimator, a Normal approximation for C is justified by noting the large sample size of the PES and invoking the central limit theorem for finite populations.

Clearly the extent of bias due to misreporting of deaths will vary from year to year. However we cannot easily quantify this variation over time. This is because the bias estimates have been derived for the first time using 2006 Census and are only re-calculated with each new Census. For this reason, for the current work, we have assumed that the misreporting rates are temporally invariant. That is, the same simulated adjustment factors have been applied in each year. Of course, this will give an underestimate of the true variation associated with the misreporting factor. However if, as seems reasonable, there is a strong correlation in the degree of Indigenous misreporting of deaths from year-to-year, then the temporal variation will be small compared to the sampling variation.

5. RESULTS OF EMPIRICAL COMPARISONS

This section presents and discusses results from a comparison of the standard and simulation methods for producing interval estimates for mortality rates. The comparison was based on two key measures:

1. The percentage change in the width of the intervals.
2. The extent of differences in the conclusions about statistical significance.

Recall that the standard method uses simple Wald confidence intervals with standard errors based on assuming a Poisson distribution for the death counts. Population counts are assumed to be without variability and no adjustment is made for misreporting of Indigenous deaths.

The approach taken was to make comparisons using real data for a range of key mortality estimates relevant to the NIRA. These estimates (corresponding to the types of comparisons described in Section 2.1) were:

TYPE 1 – INDIGENOUS/NON-INDIGENOUS GAP:

- Age-standardised Indigenous/non-Indigenous mortality rate differences by selected causes of death by jurisdiction in 2007 and in 2009.
- Indigenous/non-Indigenous child mortality rate differences by selected causes of death aggregated over the period 2004–2008.
- Age-standardised Indigenous/non-Indigenous mortality rate differences by selected causes of death aggregated over the period 2004–2008.

TYPE 2 – CHANGE IN INDIGENOUS/NON-INDIGENOUS GAP:

- Change in age-standardised mortality rate differences by selected causes of death by jurisdiction from 2007 to 2009.
- Change in Indigenous/non-Indigenous child mortality rate gap (all causes) from 2007 to 2009.

TYPE 3 – JURISDICTIONAL:

- Crude Indigenous mortality rate by selected causes of death by jurisdiction for the latest period (2009).

TYPE 4 – CHANGE IN INDIGENOUS RATES:

- Change in Indigenous child mortality rate(all causes) from 2007 to 2009.

Results for the full set of tables may be found in Appendix C.

The NIRA report requires both rate differences and ratios. For the simulation approach deriving intervals for both types of estimates is straightforward. However, to enable comparison to the standard approach (which does not handle ratios) only rate differences have been evaluated in these investigations.

General observations

The simulated interval is centred around a bias-corrected value and so has a different central location than the standard interval. This is important to note. It means that while differences in significance outcomes in the two approaches may be due to differences in variability, they may also be due to the fact that the simulation method applies a bias correction but the standard method does not.[2]

The simulation method gives noticeably wider error bands than the standard method when the adjustment factor is less than one (i.e. when inflating the observed death count for New South Wales, Queensland, South Australia and Total) and gives slightly smaller error bands when the adjustment factor is greater than one (i.e. for Western Australia and the Northern Territory). Dividing by a factor of greater than one reduces the magnitude of the adjusted death counts. This scaling tends to reduce the variance of the simulated estimate against the standard in these states, notwithstanding that the simulated estimate incorporates the additional variability of the ERP and the adjustment factor.

The contribution of the ERP to the size of the simulated intervals is much less than the contribution of adjustment factors. This is because the standard errors of the ERP are roughly half that of the standard errors on the adjustment factors.

The difference in width of error bands between the simulated and standard methods is a function of the size of the death count and the relative standard errors of the ERP and adjustment factors.[3] This means that for small death counts the replicate method gives error bands only a little larger than the standard method. For large estimates the difference is greater.

For an adjustment c, when age-standardising and differencing takes place the inflation of the difference estimate for misreporting can be much larger than $1/c$.

2 It has been suggested that the standard method could incorporate an adjustment for Indigenous misreporting of deaths, where the adjustment is treated as a constant. However to include an estimate without accounting for its variance is dubious statistical practice, and to account for the variability in the adjustment factor is not straight-forward using the standard method.

3 The magnitude of the standard error of Indigenous ERP count is around 2.5% at the national level (ABS, 2009b, p. 56). Using a Taylor series approximation for the variance of a ratio, this gives a standard error increase for the simulation method of only 0.3% for $d=10$ and an increase of 3.1% for $d=100$. This explains why the ERP variance in the replicate method does not contribute much to the increase in replicate error band over the standard unless the death counts are very large.

5.1 Indigenous / non-Indigenous child mortality rate gap, 2004 to 2008

	Certain conditions originating in the perinatal period (P00–P96)	*Symptoms, signs & abnormal clinical & laboratory findings, not elsewhere classified* (R00–R99)	*Congenital malformation, deformations & chromosomal abnormalities* (Q00–Q99)	*External causes of morbidity and mortality* (V01–Y99)	*Diseases of the respiratory system* (J00–J99)
Gap (adjusted)	55.0	33.9	7.6	23.1	10.8
Gap (unadjusted)	48.1	30.8	5.4	20.9	9.8
Simulation lower bound	39.8	25.3	0.3	16.5	6.2
Simulation upper bound	71.5	45.1	15.1	30.6	16.1
Standard lower bound	37.0	23.3	–0.9	14.5	5.6
Standard upper bound	59.3	38.2	11.7	27.2	14.0
% change in error band width	42%	33%	17%	11%	18%
Difference in outcome?	NO	NO	YES	NO	NO

	Diseases of the nervous system (G00–G99)	*Certain infectious & parasitic diseases* (A00–B99)	*Diseases of the circulatory system* (I00–I99)	*Other causes of mortality*	*Total causes of mortality*
Gap (adjusted)	3.0	2.3	6.7	8.2	150.7
Gap (unadjusted)	2.5	2.1	6.1	7.1	132.8
Simulation lower bound	0.0	0.1	3.4	3.4	117.8
Simulation upper bound	6.1	5.1	10.6	13.7	186.8
Standard lower bound	–0.5	–0.2	2.8	2.7	114.9
Standard upper bound	5.5	4.3	9.5	11.6	150.8
% change in error band width	2%	11%	7%	16%	92%
Difference in outcome?	NO	YES	NO	NO	NO

Results for comparison types 1,2 and 4

These cases have been grouped together because their results are qualitatively similar. An example table of results is given in table 5.1 to aid the discussion.

The relationship between the size of the death counts (reflected in the size of the rate differences) and the increase in the error band is clearly evident.

Also evident is the fact that, while the simulation intervals may be significantly larger than the standard intervals, the lower interval values are often similar. This is due to the adjustment factor inflating (in this case) the estimates and the fact that the simulation method will reflect the lower bounding of death counts at zero in a right-skewed interval.

The increase in variability of the simulation method over the standard method was smaller for comparisons over time than at a point in time. This is due to the fact that we observe, and hence model, very strong temporal correlations for the ERP counts, and we assume, and hence (implicitly) model, perfect temporal correlations for the Indigenous adjustment factors. Because we are looking at differences over time this mean that there is effectively no extra variability introduced by the ERP variance and adjustment factor variance.[4] The assumption of perfect temporal correlations for adjustment factors is made on conceptual grounds in the absence of observational data, as mentioned at the end of Section 4.2.

The differences in outcomes of significance testing are minor. Of 192 comparisons of type 1, 2 and 4 there were only 10 differences in conclusions, and most of those are cases of border-line significance. For National level comparisons, when outcomes differ, the standard method will tend to be slightly conservative (the reasons are given in Appendix B).

This may suggest that, despite noticeable differences in the width and location of intervals, the standard method is adequate for the key purpose of significance testing. However such a conclusion is too hasty. The current congruity of methods is due simply to the size of the comparison differences. Indigenous/non-Indigenous gaps are so large that both methods will easily find significance; temporal differences are so small that neither method will do so. We conclude that, for the present, the statistical method used is a matter of indifference, but this will not remain the case going forward.

Results for comparison types 3

Here we are comparing the crude rates for each jurisdiction. More particularly, we are comparing each jurisdiction's crude rate to the total mortality rate to see if there are significant differences between jurisdictions.[5] A subset of results are given in table 5.2.

In this case we found that a number of conclusions about statistical significance are different if the simulation method is used rather than the standard method. We found 18 out of 40 comparisons to have different outcomes. This casts real doubt about the suitability of the standard method to give reliable conclusions in this case.

4 The simulation method will still inflate/deflate the death count variance by the application of the adjustment factor. This is the sole cause of the difference between the two methods when comparing over time.

5 This was done crudely by comparing the intervals for each jurisdiction to the interval for the total, with no allowance for multiple comparisons.

5.2 Indigenous crude mortality rates in 2009

	NSW	*Qld*	*WA*	*SA*	*NT*	*Total*
	DISEASES OF THE RESPIRATORY SYSTEM					
Crude rate 2009 (adjusted)	39.0	33.3	32.5	87.8	40.8	39.0
Crude rate 2009 (unadjusted)	34.0	31.3	36.1	57.1	44.5	36.3
Simulation lower bound	27.0	23.5	20.4	45.8	26.3	32.3
Simulation upper bound	52.8	44.6	45.6	133.8	56.9	46.5
Standard lower bound	25.0	22.5	22.5	29.9	28.6	30.9
Standard upper bound	42.9	40.1	49.7	84.2	60.4	41.6
% change in error band width	44%	21%	–7%	62%	–4%	33%
Significant difference from National rate						
Simulation	FALSE	FALSE	FALSE	FALSE	FALSE	NA
Standard	FALSE	FALSE	FALSE	FALSE	FALSE	NA
Difference in outcome ?	NO	NO	NO	NO	NO	NA
	TOP 5 CAUSES OF DEATH					
Crude rate 2009 (adjusted)	325.7	319.5	409.0	604.3	444.6	375.4
Crude rate 2009 (unadjusted)	283.4	300.3	454.0	392.8	484.6	349.1
Simulation lower bound	269.2	269.8	347.8	445.7	388.9	337.7
Simulation upper bound	400.5	364.3	470.7	788.0	509.8	424.5
Standard lower bound	257.5	273.1	405.8	321.6	432.1	332.6
Standard upper bound	309.3	327.4	502.3	464.0	537.2	365.7
% change in error band width	153%	74%	27%	140%	15%	163%
Significant difference from National rate						
Simulation	FALSE	FALSE	FALSE	TRUE	FALSE	NA
Standard	TRUE	TRUE	TRUE	FALSE	TRUE	NA
Difference in outcome ?	YES	YES	YES	YES	YES	NA
	TOTAL					
Crude rate 2009 (adjusted)	413.7	430.9	531.7	841.9	581.9	493.1
Crude rate 2009 (unadjusted)	359.9	405.1	590.2	547.3	634.3	458.6
Simulation lower bound	347.7	373.9	457.6	633.7	514.0	444.7
Simulation upper bound	506.4	488.5	607.4	1087.5	661.7	561.6
Standard lower bound	330.7	373.5	535.2	463.2	574.2	439.6
Standard upper bound	389.2	436.6	645.3	631.3	694.4	477.5
% change in error band width	172%	82%	36%	170%	23%	208%
Significant difference from National rate						
Simulation	FALSE	FALSE	FALSE	TRUE	FALSE	NA
Standard	TRUE	TRUE	TRUE	FALSE	TRUE	NA
Difference in outcome ?	YES	YES	YES	YES	YES	NA

6. CONCLUSIONS

Adequately capturing the variability from different sources of error in mortality rates is a challenging task. The ABS has attempted to account for the major sources of variation in the mortality rates using a simulation approach. Empirical investigations showed that accounting for the Indigenous misreporting of deaths and its uncertainty, along with variability in the ERP counts, leads to intervals that are markedly different in width and location to the standard confidence intervals. This prompts us to conclude that the simulation method should replace the standard method for calculating confidence intervals and determining statistical significance.

For now, excepting jurisdictional comparisons, conclusions based on the alternative methods are rarely different. Given the strong theoretical basis underpinning the simulation method, the ABS has recommended it be used for all comparisons. This will alter the results of some jurisdictional comparisons, while conclusions on closing the gap will likely remain unchanged for some years. However, as the gap between Indigenous and non-Indigenous mortality outcomes closes, the two methods will start producing different outcomes. That is, the differences between outcomes at a point in time will become small enough, and change over time become large enough, that accounting for bias and extra variability will indeed lead to alternative conclusions of significance.

While the simulation methodology is well established and defensible, further work refining it is important to pursue. Clearly, the quality of the adjustment factors and the assumptions around them is one of the key weak spots of the simulation method. Hence further work has been flagged in 2013 with the completion of the quality study for the deaths to 2011 census linkage. This will mean new Indigenous misreporting adjustment factors are estimated and will be available at two time points, enabling more informed analysis of their temporal variation.

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APPENDIXES

A. STANDARD FORMULAS FOR MORTALITY INDICATORS IN THE NATIONAL INDIGENOUS REFORM AGREEMENT

Formulas are referenced from the following sources:

- Breslow, N.E. and Day, N.E. (1987) *Statistical Methods in Cancer Research*;
- Kirkwood, B.R. and Sterne, J.A.C. (1988) *Essential Medical Statistics*.

Crude death rate (and age-specific rate)

The confidence interval for a crude death rate can be calculated as:

$$CI(CDR)_{95\%} = CDR \pm 1.96 \times \frac{CDR}{\sqrt{\sum_{i=1}^{I} d_i}},$$

where

$CI(CDR)_{95\%}$ = the 95% confidence interval for the crude death rate;

d_i = the number of deaths in age group i.

Directly age-standardised death rate

The confidence interval for a direct age-standardised death rate can be calculated as:

$$CI(ASR)_{95\%} = ASR \pm 1.96 \times \sqrt{\sum_{i=1}^{I} \frac{w_i^2 d_i}{n_i^2}},$$

where

$CI(ASR)_{95\%}$ = the 95% confidence interval for the direct age-standardised death rate;

w_i = the proportion of the standard population in age group i;

d_i = the number of deaths in age group i;

n_i = the number of people in the population in age group i.

Rate difference (crude)

The confidence interval for the difference in crude death rates can be calculated as:

$$CI(CDR_1 - CDR_2)_{95\%} = \left(CDR_1 - CDR_2\right) \pm 1.96 \times \sqrt{\frac{\left(CDR_1\right)^2}{\sum_{i=1}^{I} d_{i1}} + \frac{\left(CDR_2\right)^2}{\sum_{i=1}^{I} d_{i2}}},$$

where

$CI(CDR_1 - CDR_2)_{95\%}$ = the 95% confidence interval for the difference in crude death rates;

CDR_j = the crude death rate in population j;

d_{ij} = the number of deaths in age group i in population j.

Rate difference (directly age-standardised)

The confidence interval for the difference in direct age-standardised death rates can be calculated as:

$$CI(ASR_1 - ASR_2)_{95\%} = \left(ASR_1 - ASR_2\right) \pm 1.96 \times \sqrt{\sum_{i=1}^{I} \frac{w_i^2 d_{i1}}{n_{i1}^2} + \sum_{i=1}^{I} \frac{w_i^2 d_{i2}}{n_{i2}^2}},$$

where

$CI(ASR_1 - ASR_2)_{95\%}$ = the 95% confidence interval for the difference in direct age-standardised death rates;

ASR_j = the direct age-standardised death rate in population j;

w_i = the proportion of the standard population in age group i;

d_{ij} = the number of deaths in age group i in population j;

n_{ij} = the number of people in the population in age group i in population j.

Infant mortality rate

The confidence interval for an infant mortality rate can be calculated as:

$$CI(IMR)_{95\%} = IMR \pm 1.96 \times \frac{IMR}{\sqrt{d_0}},$$

where

$CI(IMR)_{95\%}$ = the 95% confidence interval for the infant mortality rate;

d_0 = the number of deaths aged less than one year.

Infant mortality rate difference

The confidence interval for the difference in infant mortality rates can be calculated as:

$$CI(IMR_1 - IMR_2)_{95\%} = \left(IMR_1 - IMR_2\right) \pm 1.96 \times \sqrt{\frac{\left(IMR_1\right)^2}{d_{01}} + \frac{\left(IMR_2\right)^2}{d_{02}}},$$

where

$CI(IMR_1 - IMR_2)_{95\%}$ = the 95% confidence interval for the difference in infant mortality rates;

IMR_j = the infant mortality rate in population j;

d_{0j} = the number of deaths aged less than one year in population j.

B. JUSTIFICATION FOR DECLARING THE STANDARD METHOD CONSERVATIVE FOR NATIONAL COMPARISONS

For large difference estimates both standard and simulation methods produce intervals that are clearly significant. Similarly for small difference estimates that are clearly non-significant (i.e. zero is well within the interval). For small difference estimates that are border-line significant or non-significant the additional width of band due to additional variance of ERP and adjustment factor will be small (except in the unusual situation of two large estimates giving a small difference). In this situation the important factor will be the inflation to the difference estimate due to the application of the adjustment factor for the replicate method. The different cases may be pictured as follows where ( ) = standard method, [ ] = replicate method.

(i) borderline non-significance with positive difference:

```
( 0 - - - - - - | - - - - - - - )
- 0[ - - - - - - - | - - - - - - - - ]
```

(ii) borderline non-significance with negative difference:

```
( - - - - - - - - | - - - - - - - - 0 )
- - [ - - - - - - - - - | - - - - - 0 - - - - - ]
```

(iii) borderline significance with positive difference:

```
 0 ( - - - - - - - | - - - - - - - )
 0 - - [ - - - - - - - | - - - - - - - - ]
```

(iv) borderline significance with negative difference:

```
- - ( - - - - - - - | - - - - - - - - ) 0
- - - - - [ - - - - - - - - | - - - - - 0 - - ]
```

For (i) this will tend to mean that something that is borderline non-significant using the standard approach may be deemed to be significant using the replicate approach i.e. the standard approach is in fact conservative. For (ii) and (iii) the replicate method will give the same conclusion. For (iv) use of the standard method may give a conclusion of significant difference while the replicate method gives a non-significant conclusion. However because we are dealing with Indigenous/non-Indigenous comparisons, we know that this is a very unlikely scenario.

The above has been observed in practice for the two tables of national estimates compared. In table 1 there were only two out of ten difference estimates where the methods gave different conclusions. These are cases where the standard method is borderline non-significant, but the replicate method is borderline significant (i.e. type (i) above). In table 2 there was only one out of 36 difference estimates where the conclusions differ and this was again where the standard method is conservative.

In summary, whenever the standard method finds a significant difference the replicate method will give the same conclusion as the standard method (except in the unlikely case of a borderline significant negative difference). There may be some cases of small differences where the replicate method would give a significant conclusion but the standard method would not. However this means that the standard method is slightly conservative. Further, these are situations where we would want to regard 'significance' with a large degree of caution anyway.

C. FULL SET OF RESULTS TABLES FROM COMPARISONS OF SIMULATION AND STANDARD METHODS

C.1 Indigenous/non-Indigenous Mortality Rate Gap in 2007 (Age-standardised)

	NSW	*Qld*	*WA*	*SA*	*NT*	*TOTAL*
Diseases of the circulatory system (I00–I99)						
Gap (adjusted)	217.7	150.2	374.7	441.4	201.4	231.8
Gap (unadjusted)	162.3	128.5	436.5	212.0	236.7	201.0
Simulation lower bound	129.7	89.0	257.6	211.4	105.8	181.8
Simulation upper bound	328.8	244.2	506.8	729.9	301.7	302.3
Standard lower bound	100.8	65.3	317.5	74.7	132.7	163.7
Standard upper bound	223.9	191.7	555.4	349.4	340.7	238.3
% change in error band width	62%	23%	5%	89%	–6%	61%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Neoplasms (C00–D48)						
Gap (adjusted)	83.3	65.6	133.3	178.4	31.3	90.5
Gap (unadjusted)	49.4	51.4	167.7	51.8	52.2	71.8
Simulation lower bound	26.6	17.4	65.2	21.1	–38.5	58.6
Simulation upper bound	152.7	129.2	223.9	357.3	114.3	135.1
Standard lower bound	5.1	4.4	85.2	–47.5	–28.3	44.7
Standard upper bound	93.7	98.4	250.2	151.2	132.7	98.8
% change in error band width	42%	19%	–4%	69%	–5%	41%
Difference in outcome?	NO	NO	NO	YES	NO	NO
External causes of morbidity and mortality (V01–Y98)						
Gap (adjusted)	34.9	43.7	111.8	103.3	37.0	57.7
Gap (unadjusted)	25.9	38.6	128.7	53.9	47.4	51.0
Simulation lower bound	13.2	23.9	72.1	48.7	1.4	42.9
Simulation upper bound	64.1	68.7	159.3	179.4	71.0	75.9
Standard lower bound	6.8	18.0	84.6	14.0	9.7	39.4
Standard upper bound	45.1	59.2	172.8	93.8	85.1	62.7
% change in error band width	33%	9%	–1%	64%	–8%	41%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Diseases of the respiratory system (J00–J99)						
Gap (adjusted)	72.5	73.3	113.4	168.3	69.7	87.4
Gap (unadjusted)	56.6	65.3	130.9	93.0	80.4	77.7
Simulation lower bound	36.2	35.0	55.7	59.7	15.2	61.5
Simulation upper bound	121.9	126.8	179.1	296.8	127.3	119.8
Standard lower bound	23.7	24.9	65.3	18.0	19.4	56.1
Standard upper bound	89.5	105.7	196.5	167.9	141.4	99.3
% change in error band width	30%	14%	–6%	58%	–8%	35%
Difference in outcome?	NO	NO	NO	NO	NO	NO

C.1 Indigenous/non-Indigenous Mortality Rate Gap in 2007 (Age-standardised) – continued

	NSW	*Qld*	*WA*	*SA*	*NT*	*TOTAL*
Endocrine, nutritional and metabolic diseases (E00–E90)						
Gap (adjusted)	46.2	109.2	114.5	134.0	146.5	96.4
Gap (unadjusted)	37.6	101.4	129.9	78.4	163.1	88.2
Simulation lower bound	22.6	74.4	68.0	54.6	89.1	76.6
Simulation upper bound	83.1	151.6	167.7	236.6	218.7	123.9
Standard lower bound	15.2	64.3	74.8	24.4	94.8	70.0
Standard upper bound	60.1	138.5	184.9	132.3	231.5	106.4
% change in error band width	35%	4%	–9%	69%	–5%	30%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Total (top 5 diagnoses)						
Gap (adjusted)	435.9	449.9	829.5	878.2	503.1	563.1
Gap (unadjusted)	315.7	392.7	973.5	393.6	598.3	489.1
Simulation lower bound	275.3	332.3	655.3	501.1	335.0	463.8
Simulation upper bound	637.2	622.4	1038.3	1328.8	678.4	715.0
Standard lower bound	228.5	294.5	800.1	204.1	433.5	433.8
Standard upper bound	402.8	491.0	1146.9	583.2	763.2	544.4
% change in error band width	108%	48%	10%	118%	4%	127%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Other causes of mortality						
Gap (adjusted)	89.3	95.8	207.4	224.8	224.2	146.3
Gap (unadjusted)	63.2	83.6	242.0	105.9	255.1	128.4
Simulation lower bound	37.9	49.7	129.8	70.2	128.9	112.0
Simulation upper bound	147.8	160.4	294.6	423.9	321.4	192.7
Standard lower bound	23.9	38.9	159.1	6.5	156.9	101.2
Standard upper bound	102.5	128.3	324.9	205.2	353.3	155.6
% change in error band width	40%	24%	–1%	78%	–2%	48%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Total (all causes)						
Gap (adjusted)	523.4	555.3	1032.9	1124.2	722.1	709.3
Gap (unadjusted)	377.3	485.4	1211.0	513.3	847.8	617.4
Simulation lower bound	334.6	432.2	831.6	664.0	524.9	588.5
Simulation upper bound	749.3	760.7	1266.2	1658.7	939.8	894.2
Standard lower bound	281.7	376.9	1018.9	297.8	655.8	555.7
Standard upper bound	472.9	593.8	1403.1	728.9	1039.7	679.0
% change in error band width	117%	51%	13%	131%	8%	148%
Difference in outcome?	NO	NO	NO	NO	NO	NO

C.2 Indigenous/non-Indigenous Mortality Rate Gap in 2009 (Age-standardised)

	NSW	*Qld*	*WA*	*SA*	*NT*	*TOTAL*
Diseases of the circulatory system (I00–I99)						
Gap (adjusted)	203.7	151.3	193.2	337.2	130.0	177.6
Gap (unadjusted)	152.0	130.7	233.9	148.8	155.3	151.7
Simulation lower bound	121.6	86.9	119.9	131.9	45.8	129.7
Simulation upper bound	315.5	242.4	304.9	578.6	215.7	238.1
Standard lower bound	93.6	69.8	140.7	30.7	69.5	118.2
Standard upper bound	210.4	191.6	327.0	266.9	241.1	185.3
% change in error band width	66%	28%	–1%	89%	–1%	61%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Neoplasms (C00–D48)						
Gap (adjusted)	53.7	99.1	91.6	156.6	109.8	90.6
Gap (unadjusted)	24.4	82.4	121.1	39.5	135.0	72.0
Simulation lower bound	0.2	47.5	31.4	7.7	21.3	56.0
Simulation upper bound	118.5	173.1	174.4	332.1	188.5	134.8
Standard lower bound	–15.1	29.3	46.4	–59.0	48.6	45.1
Standard upper bound	63.9	135.5	195.8	137.9	221.3	98.9
% change in error band width	50%	18%	–4%	65%	–3%	46%
Difference in outcome?	YES	NO	NO	YES	NO	NO
External causes of morbidity and mortality (V01–Y98)						
Gap (adjusted)	22.4	30.3	88.3	102.2	76.0	45.2
Gap (unadjusted)	15.2	26.1	102.4	53.1	87.9	39.5
Simulation lower bound	4.9	10.8	51.2	39.9	32.7	33.4
Simulation upper bound	43.7	53.6	128.4	179.1	121.3	62.7
Standard lower bound	–0.1	8.1	62.0	17.1	39.9	29.1
Standard upper bound	30.5	44.1	142.7	89.0	135.9	49.8
% change in error band width	27%	19%	–4%	94%	–8%	41%
Difference in outcome?	YES	NO	NO	NO	NO	NO
Diseases of the respiratory system (J00–J99)						
Gap (adjusted)	82.8	71.3	66.7	129.1	21.1	73.3
Gap (unadjusted)	65.9	64.2	78.5	68.0	28.3	65.0
Simulation lower bound	44.9	36.2	27.5	30.7	–22.4	50.5
Simulation upper bound	132.3	119.6	117.4	260.9	66.0	100.6
Standard lower bound	32.4	29.0	30.8	–0.3	–17.1	45.9
Standard upper bound	99.4	99.4	126.2	136.4	73.7	84.0
% change in error band width	31%	19%	–6%	68%	–3%	32%
Difference in outcome?	NO	NO	NO	YES	NO	NO

C.2 Indigenous/non-Indigenous Mortality Rate Gap in 2009 (Age-standardised) – continued

	NSW	*Qld*	*WA*	*SA*	*NT*	*TOTAL*
Endocrine, nutritional and metabolic diseases (E00–E90)						
Gap (adjusted)	39.5	109.8	147.1	116.6	156.7	100.8
Gap (unadjusted)	31.6	101.9	165.8	67.2	173.4	92.2
Simulation lower bound	17.9	75.0	94.1	47.1	97.5	81.0
Simulation upper bound	66.8	159.3	214.0	216.5	219.9	127.5
Standard lower bound	11.5	65.7	103.9	18.2	105.5	73.9
Standard upper bound	51.8	138.0	227.8	116.3	241.4	110.5
% change in error band width	21%	16%	–3%	73%	–10%	27%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Total (top 5 diagnoses)						
Gap (adjusted)	403.0	452.3	549.0	756.2	528.0	486.9
Gap (unadjusted)	290.0	396.4	659.6	321.1	617.2	419.8
Simulation lower bound	261.6	340.2	420.3	424.1	364.3	387.2
Simulation upper bound	608.2	634.2	732.5	1169.2	684.1	616.0
Standard lower bound	207.9	299.6	513.5	144.9	462.0	368.3
Standard upper bound	372.1	493.2	805.7	497.3	772.4	471.3
% change in error band width	111%	52%	7%	111%	3%	122%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Other causes of mortality						
Gap (adjusted)	99.5	165.2	202.5	214.2	183.4	162.9
Gap (unadjusted)	72.0	149.0	237.0	97.8	212.0	143.7
Simulation lower bound	53.3	111.7	137.3	80.0	99.8	124.7
Simulation upper bound	165.4	244.7	298.7	366.2	273.5	208.7
Standard lower bound	32.5	96.4	150.3	13.5	120.6	115.9
Standard upper bound	111.5	201.6	323.7	182.2	303.5	171.5
% change in error band width	42%	26%	–7%	70%	–5%	51%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Total (all causes)						
Gap (adjusted)	500.3	617.2	761.6	1005.0	703.1	649.7
Gap (unadjusted)	360.0	545.1	907.8	441.4	819.9	563.5
Simulation lower bound	334.1	486.1	596.1	588.3	494.8	529.1
Simulation upper bound	763.2	847.2	983.2	1547.7	877.2	808.5
Standard lower bound	269.0	434.9	737.1	246.7	640.0	505.0
Standard upper bound	451.1	655.3	1078.6	636.1	999.8	622.0
% change in error band width	136%	64%	13%	146%	6%	139%
Difference in outcome?	NO	NO	NO	NO	NO	NO

C.3 Change in Indigenous/non-Indigenous Mortality Rate Gap from 2007 to 2009 (Age-standardised)

	NSW	*Qld*	*WA*	*SA*	*NT*	*TOTAL*
Diseases of the circulatory system (I00–I99)						
Change in gap (adjusted)	14.1	–1.1	181.5	104.2	71.5	54.2
Change in gap (unadjusted)	10.3	–2.2	202.6	63.3	81.4	49.3
Simulation lower bound	–90.4	–86.5	35.4	–169.5	–46.4	3.8
Simulation upper bound	101.5	107.7	305.4	383.0	190.3	112.4
Standard lower bound	–74.5	–90.0	51.5	–117.9	–53.5	–0.9
Standard upper bound	95.2	85.5	353.7	244.4	216.3	99.5
% change in error band width	13%	11%	–11%	53%	–12%	8%
Difference in outcome?	NO	NO	NO	NO	NO	YES
Neoplasms (C00–D48)						
Change in gap (adjusted)	29.6	–33.5	41.7	21.8	–78.5	–0.1
Change in gap (unadjusted)	25.0	–31.0	46.6	12.4	–82.8	–0.2
Simulation lower bound	–40.9	–116.1	–57.0	–182.1	–183.2	–38.7
Simulation upper bound	100.2	38.4	141.1	235.2	40.6	43.6
Standard lower bound	–34.3	–101.9	–64.7	–127.5	–200.8	–38.4
Standard upper bound	84.3	39.9	158.0	152.3	35.2	37.9
% change in error band width	19%	9%	–11%	49%	–5%	8%
Difference in outcome?	NO	NO	NO	NO	NO	NO
External causes of morbidity and mortality (V01–Y98)						
Change in gap (adjusted)	12.5	13.4	23.5	1.2	–39.0	12.5
Change in gap (unadjusted)	10.7	12.5	26.3	0.8	–40.5	11.6
Simulation lower bound	–16.5	–15.0	–28.0	–81.3	–97.8	–5.7
Simulation upper bound	43.4	44.8	78.2	88.5	14.8	29.8
Standard lower bound	–13.8	–14.8	–33.4	–52.9	–101.5	–4.0
Standard upper bound	35.2	39.8	86.1	54.6	20.6	27.1
% change in error band width	22%	9%	–11%	58%	–8%	14%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Diseases of the respiratory system (J00–J99)						
Change in gap (adjusted)	–10.3	2.0	46.7	39.2	48.7	14.1
Change in gap (unadjusted)	–9.3	1.1	52.4	24.9	52.0	12.7
Simulation lower bound	–63.8	–53.9	–26.7	–120.9	–18.9	–15.8
Simulation upper bound	42.0	66.2	119.3	188.8	125.2	47.1
Standard lower bound	–56.3	–52.5	–28.8	–76.5	–24.0	–16.1
Standard upper bound	37.7	54.7	133.5	126.3	128.1	41.5
% change in error band width	13%	12%	–10%	53%	–5%	9%
Difference in outcome?	NO	NO	NO	NO	NO	NO

C.3 Change in Indigenous/non-Indigenous Mortality Rate Gap from 2007 to 2009 (Age-standardised) – continued

	NSW	*Qld*	*WA*	*SA*	*NT*	*TOTAL*
Endocrine, nutritional and metabolic diseases (E00–E90)						
Change in gap (adjusted)	6.7	–0.7	–32.6	17.4	–10.2	–4.4
Change in gap (unadjusted)	6.0	–0.5	–36.0	11.1	–10.3	–4.0
Simulation lower bound	–27.4	–57.8	–106.8	–103.7	–92.0	–31.3
Simulation upper bound	44.8	54.1	42.1	136.4	74.6	23.6
Standard lower bound	–24.1	–52.3	–118.9	–61.8	–106.7	–29.8
Standard upper bound	36.2	51.3	46.9	84.1	86.1	21.8
% change in error band width	20%	8%	–10%	65%	–14%	6%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Total (top 5 diagnoses)						
Change in gap (adjusted)	32.9	–2.3	280.5	122.0	–24.9	76.2
Change in gap (unadjusted)	25.7	–3.6	313.9	72.5	–18.8	69.3
Simulation lower bound	–118.4	–152.4	59.4	–289.8	–219.5	5.4
Simulation upper bound	157.9	144.1	484.1	534.4	187.7	164.8
Standard lower bound	–94.0	–141.6	87.1	–186.3	–245.2	–6.3
Standard upper bound	145.4	134.3	540.6	331.3	207.6	144.9
% change in error band width	15%	7%	–6%	59%	–10%	5%
Difference in outcome?	NO	NO	NO	NO	NO	YES
Other causes of mortality						
Change in gap (adjusted)	–10.2	–69.4	4.9	10.6	40.8	–16.5
Change in gap (unadjusted)	–8.8	–65.5	5.0	8.0	43.1	–15.3
Simulation lower bound	–78.1	–150.0	–105.9	–183.0	–83.7	–55.0
Simulation upper bound	54.1	7.0	106.6	216.6	163.9	30.6
Standard lower bound	–64.5	–134.5	–114.9	–122.3	–91.1	–54.2
Standard upper bound	46.9	3.6	125.0	138.4	177.3	23.6
% change in error band width	19%	14%	–11%	53%	–8%	10%
Difference in outcome?	NO	NO	NO	NO	NO	NO
Total (all causes)						
Change in gap (adjusted)	23.1	–61.8	271.3	119.2	19.0	59.6
Change in gap (unadjusted)	17.2	–59.8	303.2	71.9	27.9	53.9
Simulation lower bound	–137.9	–228.6	25.6	–327.9	–208.5	–13.2
Simulation upper bound	164.0	93.9	499.5	542.5	277.6	159.2
Standard lower bound	–114.8	–214.3	46.2	–218.6	–235.2	–31.1
Standard upper bound	149.3	94.8	560.2	362.4	290.9	138.8
% change in error band width	14%	4%	–8%	50%	–8%	1%
Difference in outcome?	NO	NO	NO	NO	NO	NO

C.4 Indigenous Crude Mortality Rates in 2009

	NSW	*Qld*	*WA*	*SA*	*NT*	*TOTAL*
Diseases of the circulatory system (I00–I99)						
Crude rate (adjusted)	128.4	104.0	129.9	232.4	127.8	127.3
Crude rate (unadjusted)	111.7	97.8	144.2	151.1	139.3	118.4
Simulation lower bound	103.3	82.1	102.8	150.0	102.5	112.7
Simulation upper bound	161.0	124.3	161.1	318.1	158.2	147.2
Standard lower bound	95.5	82.3	117.0	106.9	111.1	108.8
Standard upper bound	128.0	113.2	171.4	195.2	167.5	128.0
% change in error band width	77%	36%	7%	90%	–1%	79%
Significant difference from National (simulation)	FALSE	FALSE	FALSE	TRUE	FALSE	.
Significant difference from National (standard)	FALSE	FALSE	FALSE	FALSE	FALSE	.
Difference in outcome?	NO	NO	NO	YES	NO	.
Neoplasms (C00–D48)						
Crude rate (adjusted)	87.3	86.3	101.1	129.1	104.7	95.6
Crude rate (unadjusted)	75.9	81.1	112.2	83.9	114.1	88.9
Simulation lower bound	68.1	69.0	79.2	78.0	82.2	83.5
Simulation upper bound	113.2	103.9	125.2	187.4	132.4	111.6
Standard lower bound	62.5	67.0	88.2	51.0	88.6	80.5
Standard upper bound	89.4	95.3	136.2	116.8	139.6	97.2
% change in error band width	68%	24%	–4%	66%	–2%	69%
Significant difference from National (simulation)	FALSE	FALSE	FALSE	FALSE	FALSE	.
Significant difference from National (standard)	FALSE	FALSE	FALSE	FALSE	FALSE	.
Difference in outcome?	NO	NO	NO	NO	NO	.
External causes of morbidity and mortality (V01–Y98)						
Crude rate (adjusted)	46.1	53.0	90.2	124.0	95.2	68.4
Crude rate (unadjusted)	40.1	49.8	100.2	80.6	103.7	63.6
Simulation lower bound	33.5	40.5	68.3	73.7	73.7	59.0
Simulation upper bound	61.1	67.2	112.6	183.5	120.3	80.4
Standard lower bound	30.4	38.8	77.5	48.3	79.4	56.5
Standard upper bound	49.9	60.9	122.8	112.8	128.0	70.6
% change in error band width	41%	21%	–2%	70%	–4%	52%
Significant difference from National (simulation)	FALSE	FALSE	FALSE	FALSE	FALSE	.
Significant difference from National (standard)	TRUE	FALSE	TRUE	FALSE	TRUE	.
Difference in outcome?	YES	NO	YES	NO	YES	.
Diseases of the respiratory system (J00–J99)						
Crude rate (adjusted)	39.0	33.3	32.5	87.8	40.8	39.0
Crude rate (unadjusted)	34.0	31.3	36.1	57.1	44.5	36.3
Simulation lower bound	27.0	23.5	20.4	45.8	26.3	32.3
Simulation upper bound	52.8	44.6	45.6	133.8	56.9	46.5
Standard lower bound	25.0	22.5	22.5	29.9	28.6	30.9
Standard upper bound	42.9	40.1	49.7	84.2	60.4	41.6
% change in error band width	44%	21%	–7%	62%	–4%	33%
Significant difference from National (simulation)	FALSE	FALSE	FALSE	FALSE	FALSE	.
Significant difference from National (standard)	FALSE	FALSE	FALSE	FALSE	FALSE	.
Difference in outcome?	NO	NO	NO	NO	NO	.

C.4 Indigenous Crude Mortality Rates in 2009 – continued

	NSW	*Qld*	*WA*	*SA*	*NT*	*TOTAL*
Endocrine, nutritional and metabolic diseases (E00–E90)						
Crude rate (adjusted)	24.8	42.8	55.3	31.0	76.1	45.1
Crude rate (unadjusted)	21.6	40.3	61.4	20.1	83.0	42.0
Simulation lower bound	16.0	31.3	40.6	8.9	58.4	37.7
Simulation upper bound	35.2	54.5	73.7	59.6	98.3	53.9
Standard lower bound	14.4	30.3	43.7	4.0	61.3	36.3
Standard upper bound	28.8	50.2	79.2	36.3	104.7	47.7
% change in error band width	35%	17%	–7%	57%	–8%	41%
Significant difference from National (simulation)	TRUE	FALSE	FALSE	FALSE	TRUE	.
Significant difference from National (standard)	TRUE	FALSE	FALSE	FALSE	TRUE	.
Difference in outcome?	YES	NO	NO	NO	NO	.
Total (top 5 diagnoses)						
Crude rate (adjusted)	325.7	319.5	409.0	604.3	444.6	375.4
Crude rate (unadjusted)	283.4	300.3	454.0	392.8	484.6	349.1
Simulation lower bound	269.2	269.8	347.8	445.7	388.9	337.7
Simulation upper bound	400.5	364.3	470.7	788.0	509.8	424.5
Standard lower bound	257.5	273.1	405.8	321.6	432.1	332.6
Standard upper bound	309.3	327.4	502.3	464.0	537.2	365.7
% change in error band width	153%	74%	27%	140%	15%	163%
Significant difference from National (simulation)	FALSE	FALSE	FALSE	TRUE	FALSE	.
Significant difference from National (standard)	TRUE	TRUE	TRUE	FALSE	TRUE	.
Difference in outcome?	YES	YES	YES	YES	YES	.
Other causes of mortality						
Crude rate (adjusted)	88.0	111.5	122.7	237.6	137.3	117.7
Crude rate (unadjusted)	76.6	104.8	136.2	154.4	149.7	109.5
Simulation lower bound	69.4	90.8	96.5	161.3	110.4	102.6
Simulation upper bound	113.1	133.9	150.7	324.4	169.7	136.2
Standard lower bound	63.1	88.7	109.8	109.8	120.5	100.2
Standard upper bound	90.0	120.8	162.6	199.1	178.9	118.7
% change in error band width	62%	34%	3%	83%	1%	82%
Significant difference from National (simulation)	FALSE	FALSE	FALSE	TRUE	FALSE	.
Significant difference from National (standard)	TRUE	FALSE	FALSE	FALSE	TRUE	.
Difference in outcome?	YES	NO	NO	YES	YES	.
Total (all causes)						
Crude rate (adjusted)	413.7	430.9	531.7	841.9	581.9	493.1
Crude rate (unadjusted)	359.9	405.1	590.2	547.3	634.3	458.6
Simulation lower bound	347.7	373.9	457.6	633.7	514.0	444.7
Simulation upper bound	506.4	488.5	607.4	1087.5	661.7	561.6
Standard lower bound	330.7	373.5	535.2	463.2	574.2	439.6
Standard upper bound	389.2	436.6	645.3	631.3	694.4	477.5
% change in error band width	172%	82%	36%	170%	23%	208%
Significant difference from National (simulation)	FALSE	FALSE	FALSE	TRUE	FALSE	.
Significant difference from National (standard)	TRUE	TRUE	TRUE	FALSE	TRUE	.
Difference in outcome?	YES	YES	YES	YES	YES	.

C.5 Change in Indigenous Child Mortality Rate from 2007 to 2009

	Change in Indigenous Child Mortality Rate
Change in rate (adjusted)	2.03
Change in rate (unadjusted)	1.89
Simulation lower bound	0.06
Simulation upper bound	4.22
Standard lower bound	–0.01
Standard upper bound	3.78
% change in error band width	10%
Difference in outcome?	YES

C.6 Change in Indigenous/non-Indigenous Child Mortality Rate Gap from 2007 to 2009

	Change in Indigenous/non-Indigenous Child Mortality Rate Gap
Change in gap (adjusted)	2.18
Change in gap (unadjusted)	2.04
Simulation lower bound	0.09
Simulation upper bound	4.50
Standard lower bound	0.10
Standard upper bound	3.98
% change in error band width	14%
Difference in outcome?	NO

C.7 Indigenous/non-Indigenous Mortality Rate Gap, by Gender, 2004 to 2008 (Age-standardised)

	Male	*Female*	*TOTAL*
Accidental poisoning by and exposure to noxious substances (X40–X49)			
Change in gap (adjusted)	6.0	4.6	5.3
Change in gap (unadjusted)	5.1	4.1	4.6
Simulation lower bound	3.5	2.6	3.3
Simulation upper bound	9.1	7.1	7.4
Standard lower bound	2.8	2.1	3.0
Standard upper bound	7.4	6.1	6.2
% change in error band width	21%	13%	29%
Difference in outcome?	NO	NO	NO
Assault (X85–Y09)			
Change in gap (adjusted)	8.3	6.2	7.2
Change in gap (unadjusted)	7.6	5.7	6.6
Simulation lower bound	5.9	4.5	5.5
Simulation upper bound	11.0	8.0	8.8
Standard lower bound	5.6	4.2	5.3
Standard upper bound	9.7	7.3	7.9
% change in error band width	22%	14%	30%
Difference in outcome?	NO	NO	NO
Complications of medical and surgical care (Y40–Y84)			
Change in gap (adjusted)	2.2	3.8	2.9
Change in gap (unadjusted)	1.9	3.4	2.6
Simulation lower bound	–0.4	1.5	1.2
Simulation upper bound	5.6	6.2	4.8
Standard lower bound	–0.8	1.4	1.0
Standard upper bound	4.7	5.5	4.2
% change in error band width	9%	14%	12%
Difference in outcome?	NO	NO	NO
Accidental drowning and submersion and other threats to breathing (W65–W84)			
Change in gap (adjusted)	7.5	1.8	4.2
Change in gap (unadjusted)	6.7	1.5	3.7
Simulation lower bound	3.9	0.5	2.5
Simulation upper bound	11.7	3.3	6.2
Standard lower bound	3.3	0.3	2.1
Standard upper bound	10.1	2.8	5.3
% change in error band width	13%	12%	13%
Difference in outcome?	NO	NO	NO

C.7 Indigenous/non-Indigenous Mortality Rate Gap, by Gender, 2004 to 2008 (Age-standardised) – continued

	Male	*Female*	*TOTAL*
Exposure to electric current, radiation, etc. (W85–W99)			
Change in gap (adjusted)	3.2	2.7	2.9
Change in gap (unadjusted)	2.9	2.4	2.6
Simulation lower bound	1.2	1.1	1.7
Simulation upper bound	5.6	4.3	4.3
Standard lower bound	1.0	0.9	1.5
Standard upper bound	4.8	3.9	3.8
% change in error band width	12%	7%	9%
Difference in outcome?	NO	NO	NO
Exposure to inanimate mechanical forces (W20–W49)			
Change in gap (adjusted)	1.1	0.7	0.9
Change in gap (unadjusted)	0.9	0.6	0.7
Simulation lower bound	0.0	0.2	0.2
Simulation upper bound	2.3	1.4	1.5
Standard lower bound	–0.2	0.1	0.2
Standard upper bound	1.9	1.2	1.3
% change in error band width	7%	14%	10%
Difference in outcome?	YES	NO	NO
Falls (W00–W19)			
Change in gap (adjusted)	4.0	–2.8	0.0
Change in gap (unadjusted)	3.1	–3.1	–0.5
Simulation lower bound	–0.2	–5.0	–2.2
Simulation upper bound	8.9	–0.5	2.6
Standard lower bound	–1.2	–5.3	–2.7
Standard upper bound	7.5	–0.9	1.7
% change in error band width	4%	4%	8%
Difference in outcome?	NO	NO	NO
Intentional self-harm (X60–X84)			
Change in gap (adjusted)	15.7	1.9	8.5
Change in gap (unadjusted)	13.1	1.3	6.9
Simulation lower bound	10.0	0.0	5.3
Simulation upper bound	22.1	3.9	11.9
Standard lower bound	9.0	–0.2	4.9
Standard upper bound	17.1	2.9	9.0
% change in error band width	51%	23%	62%
Difference in outcome?	NO	NO	NO

C.7 Indigenous/non-Indigenous Mortality Rate Gap, by Gender, 2004 to 2008 (Age-standardised) – continued

	Male	*Female*	*TOTAL*
Transport accidents (V01–V99)			
Change in gap (adjusted)	17.9	9.7	13.7
Change in gap (unadjusted)	15.6	8.7	12.0
Simulation lower bound	12.7	6.8	10.1
Simulation upper bound	24.0	12.9	17.6
Standard lower bound	11.6	6.1	9.6
Standard upper bound	19.6	11.3	14.3
% change in error band width	41%	17%	62%
Difference in outcome?	NO	NO	NO
Other external causes of accidental injury			
Change in gap (adjusted)	7.3	4.7	5.6
Change in gap (unadjusted)	6.4	4.0	4.8
Simulation lower bound	2.5	1.4	2.8
Simulation upper bound	13.2	8.1	8.8
Standard lower bound	1.6	0.8	2.1
Standard upper bound	11.3	7.2	7.5
% change in error band width	10%	5%	11%
Difference in outcome?	NO	NO	NO
Other external causes of mortality			
Change in gap (adjusted)	7.9	1.9	4.5
Change in gap (unadjusted)	7.1	1.7	4.0
Simulation lower bound	4.3	0.6	2.7
Simulation upper bound	11.7	3.4	6.2
Standard lower bound	3.7	0.4	2.4
Standard upper bound	10.5	3.0	5.6
% change in error band width	9%	9%	8%
Difference in outcome?	NO	NO	NO
Total external causes of mortality			
Change in gap (adjusted)	74.8	30.3	50.2
Change in gap (unadjusted)	64.5	25.9	43.0
Simulation lower bound	56.7	21.7	37.4
Simulation upper bound	96.3	40.7	63.9
Standard lower bound	53.9	19.8	37.3
Standard upper bound	75.1	32.0	48.8
% change in error band width	87%	55%	132%
Difference in outcome?	NO	NO	NO

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