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Synthesising Estimates of Indigenous Child Health Based on the W.A. Aboriginal Child Health Survey

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Terry Rawnsley, Sarah Dexter and Katie Palin

Analytical Services Branch

Methodology Advisory Committee

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INQUIRIES

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For further information, please contact Mr Jonathon Khoo, Analytical Services Branch on Canberra (02) 6252 5506 or email <jonathon.khoo@abs.gov.au>.

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SYNTHESISING ESTIMATES OF INDIGENOUS CHILD HEALTH BASED ON THE W.A. ABORIGINAL CHILD HEALTH SURVEY

Terry Rawnsley, Sarah Dexter and Katie Palin
Analytical Services Branch

ABSTRACT

The Western Australian Aboriginal Child Health Survey (WAACHS) was the first large-scale epidemiological survey of Indigenous children in Australia. It provides detailed information about the health, mental health, education and other socioeconomic outcomes for Indigenous children in Western Australia.

Given that Queensland and the Northern Territory also have a substantial Indigenous population, these jurisdictions would find information similar to the WAACHS most useful in policy development and service provision. This paper examines the feasibility of using the WAACHS and other nationally available datasets to model key indicator variables for Queensland and the Northern Territory.

The methods and results described in this paper represent development work as at June 2005. Comments from the Methodology Advisory Committee (MAC) prompted additional analyses to investigate the validity of various methodological assumptions. A summary of this work is provided as an appendix to this paper, and is the subject of a report that will be released in early 2007.

The models described in this paper appeared to produce promising results. However, additional analysis found that there is insufficient evidence to prove or disprove key assumptions for the synthetic estimation method. This means it is not feasible to derive synthetic estimates for Queensland and the Northern Territory based on the WAACHS.

1. INTRODUCTION

1.1 Background

The Methodology Advisory Committee (MAC) were presented a draft version of this paper to review a synthetic method of estimating Indigenous child health and wellbeing for regions in Queensland and the Northern Territory based on the Western Australian Aboriginal Child Health Survey (WAACHS). The methods and results described in this paper represent development work as at June 2005. The MAC raised concerns about the validity of key methodological assumptions underlying the estimation method.

Further work was undertaken after the MAC meeting to analyse the validity of these assumptions. This additional work is the subject of a report that will be released in early 2007, and a summary of this can be found in Appendix D. We found that there is insufficient evidence to prove or disprove the assumptions underlying the synthetic estimation method.

1.2 Introduction

The Indigenous population in Australia have health outcomes far below those of the rest of the population (Australian Bureau of Statistics, 2001). Many of the health conditions suffered by Indigenous people can be linked to factors which appear at a very early age or even before birth (Zubrick *et al.*, 2004b). This project explored the feasibility of synthesising estimates of Indigenous child health and wellbeing for regions in Queensland and the Northern Territory based on WAACHS.

WAACHS was conducted by the Telethon Institute for Child Health Research (TICHR) from May 2000 to June 2002 and was the first large-scale epidemiological survey of Indigenous children and young people in Australia. The primary objective of the WAACHS was to identify the developmental and environmental factors affecting the health of Indigenous children and young people.

Extrapolated synthetic estimates will generally not be as accurate as estimates from a sample survey. However, they could provide a broad indication of the distribution of key variables for areas (in this study each ATSIC region in Queensland and the Northern Territory [1]). Extrapolating estimates to Queensland and the Northern Territory is an extreme case of an out of sample estimation problem.

1 With the abolition of ATSIC Regional Councils and the establishment by the Office of Indigenous Policy Coordination of regional Indigenous Coordination Centres (ICCs), changes have been made to the geographic regions used for producing statistics in relation to Aboriginal peoples. While it is recognised that ATSIC regions no longer exist, we have kept these regions to provide continuity with other WAACHS products.

Section 1 introduces the project and the input sought from the MAC. Section 2 presents the nature of the problem while Section 3 describes the methods investigated along with some preliminary results. Section 4 concludes the paper.

1.3 Project overview

This feasibility study began in early 2005. At June 2005, the project team had:

- Become familiar with the WAACHS and the data sources which are seen as potentially having the most use in the project. Appendix B provides a brief overview of the data sources that could be used for estimation or validation of results.
- Identified appropriate estimation methods.
- Modelled a limited number of variables to understand the methods and the problems which will have to be addressed.
- Started testing some of the assumptions underpinning the models.

1.4 Input sought from the Methodology Advisory Committee

The project team sought input from MAC on the following points:

- Do the proposed methods appear to be reasonable for the problem at hand?
- Are there ways to validate the models specified for Western Australia , Queensland and the Northern Territory?
- How can we make best use of the auxiliary data we have available?
- Any other insights MAC may have.

2. THE NATURE OF THE PROBLEM

Extrapolating estimates to Queensland and the Northern Territory represents an extreme case of an out of sample estimation problem. This technical problem is a particular form of small area estimation, where survey data is modelled to produce results at a fine level of disaggregation. However, there is no measured response variable (*Y* variable) for Queensland and the Northern Territory.

Figure 2.1 is used to illustrate the problem (in its most simple linear form). In Western Australia we were able (via the WAACHS) to measure both the response and explanatory variables and specify a model. However, only the explanatory variables were available in Queensland and the Northern Territory. So, the parameters from Western Australia could be applied to the explanatory variables in Queensland and the Northern Territory in order to make predictions for those jurisdictions.

2.1 Nature of the problem

$$y_{WA_j} = \beta_{1WA} + \beta_{2WA} x_{1WA_j} + \beta_{3WA} x_{2WA_j} + e_{WA_j}$$

$$\hat{y}_{QLD_j} = \hat{\beta}_{1WA} + \hat{\beta}_{2WA} x_{1QLD_j} + \hat{\beta}_{3WA} x_{2QLD_j}$$

$$\hat{y}_{NT_j} = \hat{\beta}_{1WA} + \hat{\beta}_{2WA} x_{1NT_j} + \hat{\beta}_{3WA} x_{2NT_j}$$

where j is each child, β are the model coefficients and x are the explanatory variables. The estimates for Queensland and the Northern Territory were based on the relationship between the response and explanatory variables observed in Western Australia.

Key assumptions are imposed when applying the Western Australian models to Queensland and the Northern Territory. The fundamental assumption is that the relationships identified for Western Australia are similar to those in Queensland and the Northern Territory. That is, state or territory has no impact on health outcomes after taking into account an individual's social and economic circumstances.

Our initial descriptive analysis (not presented in this paper) showed that the distribution and patterns of related health variables were similar across the three jurisdictions. For this method to be feasible, we assumed that this similarity would also hold for the response variables which we tried to model. However, we could not conclude from this descriptive analysis that the underlying factors associated with these variables were the same for each jurisdiction.

The models from the WAACHS were applied to the ABS 2001 National Health Survey Indigenous component (NHS(I)). This collection was chosen because it includes relevant health information about carers and children which could be useful in modelling. A number of models were specified including these health variables and other models that only include 'demographic' variables. The sampling error in the explanatory variables was not been taken into account.

There is also the issue of consistency between the variables collected in the different data sets. That is, the concept underlying each variable is the same in the different data sets. It is ABS practice to collect survey data using standard definitions (and questions) and the WAACHS development drew on ABS standards.

For the feasibility study, three variables were modelled to test how viable the estimation for Queensland and the Northern Territory is using the WAACHS. The variables chosen were:

- Low birth-weight (less than 2,500 grams).
- Self-harm (deliberately harmed self, talked about death or suicide, attempted suicide).
- Tropical ear (ever suffered from runny/glue ears).

These three variables were chosen as they represent a diverse set of variables which should help identify issues associated with creating synthetic estimates of Indigenous children health for Queensland and the Northern Territory.

3. METHODOLOGY

3.1 Area level models

The Poisson distribution is regarded as the "benchmark model for count data" (Cameron & Trivedi, 1998). The Poisson distribution seemed appropriate in this case given we modelled counts of children with certain health conditions. That is, the response variable (y) is a discrete random variable with a Poisson distribution with parameter $\mu_i > 0$, such that:

$$P(y_i \mid X_i) = \frac{e^{-\mu_i} \mu_i^{y_i}}{y_i!}, \; y_i = 0, 1, 2, \ldots$$
$$\log \mu_i = X_i' B$$

where

X_i = the matrix of explanatory variables,

B = the vector of regression coefficients.

The Poisson model assumes that the conditional variance is equal to the mean, μ_i. Unfortunately this assumption rarely holds; instead we must relax the variance assumption to account for over-dispersion. The new assumption is that the conditional variance is given by:

$$Var(y_i \mid X_i) = \mu_i + g\mu_i^r$$

where g is the dispersion parameter, which would be equal to zero under a true Poisson distribution. However, $g > 0$ if the distribution of the data is over-dispersed. The value of r describes the form of over-dispersion. Here we used $r = 1$, as this is what SAS implements and so the variance function takes the form $\mu_i + g\mu_i$. This, of course, may not correctly adjust for the over-dispersion present in the data.

While the Poisson regression appeared to be well suited to this case, the real test comes when the models are specified and the results examined. The number of children born with low birth-weight in each ATSIC region in Western Australia is the dependent variable in this example. The explanatory variables in the model are:

- The number of children born to mothers who consumed alcohol during the pregnancy in the ATSIC region. This was collected on the WAACHS.
- The number of children born to mothers who consumed cigarettes during the pregnancy in the ATSIC region. This was collected on the WAACHS.
- The average ARIA++ score for the ATSIC region (see Appendix B for more information on ARIA++). This was constructed from variables on the Census.

- The SEIFA Index of Relative Socio-economic Advantage/Disadvantage score for the ATSIC region. This was constructed from variables on the Census.

The pseudo R-squared for this model was 64.7 (based on the decomposition of deviance (Cameron and Windmeijer, 1997)). The results from the Poisson regression were somewhat disappointing. In general the model estimates were not close to the direct estimates from the WAACHS.

There are a number of possible reasons why the Poisson regression performed so poorly. There was only a very limited number of ATSIC regions in Western Australia (nine) to base the model on. Also the exact form of the over-dispersion of the data may have been different, and not been fully accounted for in this model.

ATSIC regions were established for administrative purposes rather than as areas consisting of homogenous populations (perhaps a good example of the ecological fallacy). In general, ATSIC regions consist of one large population centre [2] and a wider area which is relatively sparsely populated. So the characteristics of the Indigenous children in the area are quite heterogeneous. Therefore, the very nature of the ATSIC regions could be the main reason why the area based Poisson model performed so poorly (relative to the person level models presented in the next section).

The Poisson models for the other chosen variables (self-harm and tropical ear) also performed quite poorly.

Overall, a number of different problems have been identified with the area based Poisson regression models. However, this is not the only method which could be suitable for this particular problem. The next section investigates using person level models.

3.2 Person level models

We also investigated modelling at the person level. While the modelling may be undertaken at the person level, there is no desire to use the data at this level. Rather, the results from the person level would be aggregated up to be reported at the ATSIC region or other broad breakdowns for each jurisdiction. Modelling at the person level allows for more differentiation between the characteristics of each child than area based models.

The WAACHS is an example of a multistage clustered sample survey. A sample of CDs/communities (CDs in urban areas and communities in remote areas) were selected at the first stage. At the second stage Indigenous families were selected and then every Indigenous child under the age of 18 was included in the survey.

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2 The size of the service centre can vary dramatically from a population centre of a few thousand people or a major city of a million or more people.

Probability Weighted Iterative Generalised Least Squares (PWIGLS) can be used to fit a multilevel level model which accounts for the survey design. This method (proposed by Pfeffermann *et al.*, 1998) was applied to a two level model with normally distributed continuous variables. TICHR extended this method to include three levels (CD, family, child) and to enable the fitting of a logistic regression (Zubrick *et al.*, 2004a).

The person level models here take a logistic form. The general form of the model is:

$$y_{ij} \sim Bern(1, p_{ij})$$
$$\text{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = X_{ij}B$$

where

p_{ij} = whether child *j* in area *i* was born with low birth-weight,

X_{ij} = the matrix of explanatory variables,

B = the vector of regression coefficients.

The explanatory variables were the child's age, maternal age of the mother, sex of the child, ARIA++ (see Appendix A for explanation) and a dummy variable if more than 20 of the population in the ATSIC region are Indigenous. The models from the WAACHS were then applied to the NHS(I) to produce estimates for Western Australia. The variables being used are conceptually the same in both data sets.

The underlying WAACHS and NHS(I) data were examined to ensure that they are empirically consistent. This examination revealed some differences between the sampling strategies for NHS(I) and WAACHS.[3] For example, in the Broome ATSIC region, the NHS(I) sample was four times the WAACHS sample. Not surprisingly this has an impact on the quality of some of the estimates.

The coefficients from the PWIGLS were fed into the Windows Bayesian Inference Using Gibbs Sampling (WINBUGS) (Spiegelhalter *et al.*, 1997) as starting values for each coefficient. WINBUGS was used to create the measures of prediction error from posterior distributions. This method was chosen due to the complexity of calculating Mean Squared Errors (MSEs) and time constraints for the feasibility study.

This modelled probability was then applied to each child in the NHS(I). The number of children with low birth-weight were estimated and then converted into rates.

The Iterative Generalised Least Squares (IGLS) approach does not maximise a likelihood function and this creates difficulties in producing a pseudo R-squared. With the multilevel model (in this case three levels, CD – carers – children) we found that

3 The technical issues relating to the auxiliary data used in the modelling is discussed further in Appendix A.

two thirds of total variance is explained by the child and the carer level. Therefore, does it then make sense to construct an R-squared measure that says x of the total variance situated at the child and carer level is explained by the model?

Table 3.1 compares the direct estimates from the WAACHS with modelled estimates from the NHS(I) for each ATSIC region in Western Australia. Modelled estimates were obtained using a person level model. The prediction error from posterior distributions provides an indication of the reliability of the estimates for each ATSIC region. However, MSEs are still seen as the better measure of the quality of the estimates.

3.1 Direct estimates from WAACHS and person model estimates from NHS(I) for low birth-weight

ATSIC Region	*Lower CI*	*WAACHS direct estimate*	*Upper CI*	*Posterior Lower CI*	*Estimate based on NHS(I)*	*Posterior Upper CI*
Broome	6.4%	10.7%	17.1%	10.8%	14.2%	18.2%
Derby	12.1%	17.8%	24.6%	10.1%	13.4%	17.1%
Geraldton	8.4%	12.3%	17.6%	9.8%	10.9%	12.1%
Kalgoorlie	3.2%	5.7%	9.2%	7.3%	10.4%	14.3%
Kununurra	7.0%	10.1%	13.6%	10.2%	13.8%	18.2%
Narrogin	8.7%	11.7%	15.6%	9.6%	10.8%	12.1%
Perth	8.5%	10.7%	13.3%	9.4%	10.8%	12.2%
South Hedland	7.6%	12.0%	17.2%	9.1%	11.0%	13.1%
Warburton	4.5%	13.0%	28.8%	9.7%	12.6%	15.9%

It is also possible for a model with a high goodness of fit to give predictions with high prediction error and vice versa. Researchers tend to focus on the prediction error because that is what is most important in this situation.

Synthetic models may produce quite poor results for areas that have unique characteristics (that are not accounted for in the model) causing them to be at the extremes of the distribution. There is the option to exclude areas with extreme values from the model estimation. This may lead to improved estimates for the remaining areas, although the inclusion of areas with extreme values may improve the estimates for the other jurisdictions with outliers. Appendix C presents estimates of Relative Standard Errors and the Root Relative Posterior Variance.

Overall the model appeared to be producing results which are quite close to the direct estimates from the WAACHS. The confidence interval, based on the posterior variance, also suggest that the estimates were relatively robust for low birth-weight. However, the rankings for the ATSIC regions based on the model predictions were quite different to those based on the direct estimates.

In table 3.2, the results from the modelled estimates for self-harm are compared to the direct estimates from the WAACHS for each ATSIC region. The explanatory variables in the self-harm model were the child's age, sex of the child, ARIA++, SEIFA (advantage/disadvantage index in quartiles) and a dummy variable if more than 20 of the population in the ATSIC region is Indigenous.

3.2 Direct estimates from WAACHS and person model estimates from NHS(I) for self-harm

ATSIC Region	*Lower CI*	*WAACHS direct estimate*	*Upper CI*	*Posterior Lower CI*	*Estimate based on NHS(I)*	*Posterior Upper CI*
Broome	16.0%	26.4%	37.6%	12.8%	16.5%	20.7%
Derby	6.2%	15.3%	32.0%	5.5%	7.3%	9.4%
Geraldton	4.3%	8.6%	14.5%	5.9%	7.2%	8.7%
Kalgoorlie	3.7%	6.3%	10.5%	2.2%	3.1%	4.1%
Kununurra	3.6%	5.8%	8.6%	4.1%	6.2%	8.5%
Narrogin	6.4%	9.9%	14.4%	6.0%	7.2%	8.6%
Perth	10.3%	12.8%	15.9%	14.4%	16.6%	19.0%
South Hedland	4.4%	8.2%	14.2%	4.8%	6.5%	8.2%
Warburton	0.3%	3.1%	9.5%	6.2%	8.0%	10.0%

When compared to the direct estimates from the WAACHS, the estimates for Broome and Derby were poor (although there are large confidence intervals around the direct estimates). Once again these are the ATSIC regions which were at the extremes of the distribution. As with low birth-weight the rankings for the ATSIC regions were quite different for the model predictions compared to the direct estimates.

3.3 Direct estimates from WAACHS and person model estimates from NHS(I) for tropical ear

ATSIC Region	*Lower CI*	*WAACHS direct estimate*	*Upper CI*	*Posterior Lower CI*	*Estimate based on NHS(I)*	*Posterior Upper CI*
Broome	18.6%	24.1%	60.5%	21.7%	25.8%	30.0%
Derby	23.6%	28.0%	32.9%	22.4%	27.6%	33.1%
Geraldton	19.2%	23.6%	28.7%	18.4%	19.9%	21.3%
Kalgoorlie	16.0%	21.5%	28.0%	18.8%	25.6%	33.9%
Kununurra	20.0%	24.6%	29.7%	23.0%	28.3%	33.9%
Narrogin	15.0%	18.0%	21.3%	18.7%	20.6%	22.6%
Perth	16.0%	18.4%	20.9%	16.5%	18.1%	19.7%
South Hedland	19.6%	25.7%	32.8%	18.6%	21.6%	25.0%
Warburton	23.5%	29.9%	36.6%	22.2%	26.8%	31.6%

Table 3.3 compares the same estimates for tropical ear. The explanatory variables in the tropical ear model were the child's age, sex of the child, ARIA++ and a dummy

variable if more than 20 of the population in the ATSIC region is Indigenous. As with the other two variables, this relatively simple model appeared to be producing reasonable results for the ATSIC regions in Western Australia.

Overall these person level models appeared to be capable of producing viable results for the majority of ATSIC regions in Western Australia. The next section discusses the inclusion of random effects to improve the models.

3.3 Random effects

The inclusion of random effects could potentially improve the estimates at the ATSIC region level. In principle a random effect model appeared suitable for this feasibility study. However, the problem is how could we estimate a random effect where there is no sample? In this case we were applying the relationships from Western Australia to Queensland and the Northern Territory, and the use of random effects at the ATSIC region level was not possible. For example, there is not a Warburton ATSIC region (or comparable ATSIC Region) in Queensland and the Northern Territory.

The ATSIC region was not the only area classification which could possibly be used. LORI (Level of Relative Isolation) is based on road distance to the nearest service centre and contains five categories of areas (see Appendix B for more information on LORI). The LORI categories group together areas which are far more homogenous than the ATSIC regions. For example, the Perth and Brisbane ATSIC regions are both classified as the same LORI category. So, the random effects could be included into the model for each LORI category, and the result will still be presented for each ATSIC region level.

In general, the random effects will be included as follows:

$$\text{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = X_{ij}B + \nu_L$$

The random effect parameters ν_L (for each LORI category) enter the model in a linear form. It would be ideal to include the random effect when running the PWIGLS model. However, the inclusion of random effects with PWIGLS required additional time and resources to accomplish. We estimated the random effects in WINBUGS.

The Hausman test was used to indicate whether random effects are adding explanatory power to the model. The Hausman test is testing the hypothesis that

$$E\left(\nu_L \mid X\right) = 0$$

If this null hypothesis test is true, then the random effects estimator is consistent and efficient. If the null hypothesis is rejected, the random effects estimator is not consistent and the fixed effects model is more appropriate.

The random effect estimator was not consistent in the birth-weight model. Therefore, the results are not presented here. This was not surprising given that the probability of a child being born with low birth-weight should be more related to the mother's individual characteristics rather than the characteristics of the area in which she lived. Of course, there may still be some correlation between the area and characteristics of the mother. For example, a mother living in a very remote area may not have easy access to fresh food and medical expertise which could have an impact on the birth-weight of a child. Or conversely living in a very remote area may help protect the mother (for example, if a traditional lifestyle is followed) from poor diet or drug and alcohol abuse.

Table 3.4 compares the random effect model estimates with the direct WAACHS estimates for self harm. With the random effects included, Broome, Kununurra and Warburton all produced estimates which were closer to the direct estimates from the WAACHS. South Hedland was the only ATSIC region which was (considerably) adversely affected by the inclusion of random effects. We believe this is due to almost all of South Hedland being in the 'High' LORI category. A large proportion of the Broome ATSIC region is also in the 'High' LORI category. The Broome ATSIC region has the highest level of self-harm while South Hedland is lowest. This may be the source of problems for these ATSIC regions' estimates.

3.4 Direct estimates from WAACHS and random effect model estimates from NHS(I) for self-harm

ATSIC Region	*Lower CI*	*WAACHS direct estimate*	*Upper CI*	*Posterior Lower CI*	*Estimate based on NHS(I)*	*Posterior Upper CI*
Broome	16.0%	26.4%	37.6%	13.3%	17.1%	21.4%
Derby	6.2%	15.3%	32.0%	4.3%	6.1%	8.4%
Geraldton	4.3%	8.6%	14.5%	5.9%	7.4%	9.1%
Kalgoorlie	3.7%	6.3%	10.5%	2.0%	2.8%	3.8%
Kununurra	3.6%	5.8%	8.6%	3.4%	5.2%	7.6%
Narrogin	6.4%	9.9%	14.4%	5.6%	7.0%	8.6%
Perth	10.3%	12.8%	15.9%	13.6%	16.1%	18.6%
South Hedland	4.4%	8.2%	14.2%	5.7%	8.3%	11.1%
Warburton	0.0%	3.1%	9.5%	5.0%	6.9%	9.1%

Table 3.5 compares the random effect model estimates with the direct WAACHS estimates for tropical ear. The estimates from the random effect model for tropical ear were quite similar to the results from the non-random effect model. However, Confidence Intervals are wider for the random effect model. The random effect model will capture more of the variation which exists between the different LORI categories.

3.5 Direct estimates from WAACHS and random effect model estimates from NHS(I) for tropical ear

ATSIC Region	*Lower CI*	*WAACHS direct estimate*	*Upper CI*	*Posterior Lower CI*	*Estimate based on NHS(I)*	*Posterior Upper CI*
Broome	18.6%	24.1%	60.5%	18.5%	26.0%	35.0%
Derby	23.6%	28.0%	32.9%	15.6%	28.0%	43.2%
Geraldton	19.2%	23.6%	28.7%	17.9%	19.6%	21.3%
Kalgoorlie	16.0%	21.5%	28.0%	14.9%	27.0%	42.0%
Kununurra	20.0%	24.6%	29.7%	16.5%	28.9%	43.4%
Narrogin	15.0%	18.0%	21.3%	17.9%	20.0%	23.0%
Perth	16.0%	18.4%	20.9%	16.6%	18.3%	20.2%
South Hedland	19.6%	25.7%	32.8%	18.3%	22.5%	26.8%
Warburton	23.5%	29.9%	36.6%	17.0%	27.3%	40.0%

3.4 Estimates for Queensland and the Northern Territory

The models appeared to be producing reasonable results for Western Australia. However, we still needed to test the assumption that the models would produce reliable results in Queensland and the Northern Territory. To do this we needed data from an independent source that could be used to help validate modelled estimates.

There are data available for birth-weight from the Australian Institute of Health and Welfare (AIHW). Although the scope [4] and timing [5] of the collections are different to the WAACHS, the AIHW data do provide some indication of how reliable the estimates might be for the two other jurisdictions.

The model estimates for Queensland and the AIHW data were quite close for most ATSIC regions. However, there were some discrepancies for the Torres Strait Islands. For the Northern Territory, the model estimates were also promising.

4 AIHW data relates to children born to Indigenous mothers; the WAACHS relates to indigenous children.

5 AIHW data is for 1991–1996, while the WAACHS data is for 1984–2002.

4. CONCLUDING REMARKS

This paper describes some of the key methodological issues when trying to produce synthetic estimates. A number of different modelling techniques were explored to assess their feasibility for synthetic estimation and these appeared to show promising results. The results in this paper represent work in progress at June 2005. At that stage the project team were seeking advice from MAC members on the broad approach taken.

Comments at the MAC meeting suggested that the key methodological assumptions needed further validation. Subsequent work could neither prove nor disprove the validity of these assumptions, and the synthetic estimation was deemed infeasible given the current national data sources available. This extension was a substantial piece of work in its own right, and is the subject of a report to be released in early 2007. A brief summary of this work is provided in Appendix D.

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APPENDIXES

A. ISSUES RELATED TO THE AUXILIARY DATA

The preliminary modelling undertaken appeared to be producing encouraging results. However, the reliability of any modelling is heavily dependent on the quality of the input data. The 2001 NHS(I) collects a number of potentially useful explanatory variables that are common to the WAACHS, but the NHS(I) has quite a small sample size. The NHS(I) was designed to produce reliable estimates at the national level for persons in scope of the survey. The sample design was based on a broad dissection of Australia into non-sparsely settled and sparsely settled areas. Also, not all Indigenous children in a household were sampled in the NHS(I). For example, households selected in non-sparsely settled areas only had one adult (aged 18 years and over) and up to two children aged 0–17 years selected. In households selected in sparsely settled areas, one adult (aged 18 years and over) and only one child aged 0–17 years were selected.

Table A.1 compares the sample sizes from the WAACHS and the NHS(I) for each ATSIC region. Given the large sample of the WAACHS, we would not expect the same quality from similar breakdowns of the model estimates based on the NHS(I). For example, in most of the results presented in this paper, differences could be due to the small sample size of some ATSIC regions. Improved results may be possible with larger sample sizes within these regions.

A.1 Sample sizes from the WAACHS and NHS(I) for WA

ATSIC Region	*WAACHS*	*NHS(I)*
Broome	213	51
Derby	290	36
Geraldton	624	36
Kalgoorlie	325	16
Kununurra	370	12
Narrogin	1,020	32
Perth	1,748	64
South Headland	369	48
Warburton	330	25

B. DATA USED BY THE PROJECT

Western Australian Aboriginal Child Health Survey (WAACHS)

The WAACHS was a large scale survey, conducted by the Telethon Institute of Child Health Research (TICHR), measuring the health and wellbeing of over 5,000 Western Australian Aboriginal and Torres Strait Islander children and young people and was run for the first time from May 2000 to June 2002. The primary objective of the survey was to identify the developmental and environmental factors affecting Indigenous children and young people. In this survey Indigenous children and young people includes all those 17 years and under who are identified by their carers as either Aboriginal or Torres Strait Islander.

The data was collected directly from children and young people, their carers and their teachers, and then linked to administrative records (health and education) associated with the child.

The WAACHS includes information on children's health, wellbeing and education as well as demographic and social characteristics of their household and family. Information collected in the survey includes dental health, hearing, birth-weight, diet, admission to hospital, language spoken, violence in the family and mothers' alcohol and drug use while pregnant. Separate data on the health and wellbeing of a child was also collected directly from those children aged 12 to 17 years. For further information, please refer to *The Health of Aboriginal Children and Young People, Volume 1*, Telethon Institute of Child Health Research.

2001 National Health Survey Indigenous (NHS(I))

The NHS(I) obtained detailed information on the health status of the Indigenous population and was designed to produce reliable estimates at the national level. The survey included Indigenous people of all ages and was conducted from February to November 2001 and previously in 1995. The NHS(I) collected data from 3,198 Aboriginal and Torres Strait Islanders (1,853 adults, 18 years and over and 1,828 children, under 18).

The survey was designed to collect information on a wide range of health issues of Indigenous Australians. The NHS(I) collected information on self assessed health status, use of health services, health related lifestyle aspects and demographic characteristics. For further information, please refer to *National Health Survey: Aboriginal and Torres Strait Islander Results, Australia*, ABS cat. no. 4715.0.

Census of Population and Housing

The Australian Census of Population and Housing is conducted every five years. The 2001 Census data used in this project was included to support the analysis at levels the sample surveys could not. Data is collected on a wide variety of topics, including demographic information and geographic detail. Estimates from the Census contain no sampling error as the total population is enumerated.

National Aboriginal and Torres Strait Islander Social Survey (NATSISS)

The NATSISS is a cross-cutting social survey of Australia's Indigenous population. It was first conducted in 1994. The survey was designed to enable analysis on the interrelationships of social circumstances and outcomes of Aboriginal and Torres Strait Islander Australians. The survey was conducted from August 2002 to April 2003, collecting information from 9,400 Indigenous Australians aged 15 years and over. Some basic information was also collected about the number of children under 15 living in the same household as the survey respondent.

Information collected from the NATSISS covered topics including family and community, culture and language, health, income and housing, education, employment, law and justice, information technology and transport. For further information, please refer to National Aboriginal and Torres Strait Islander Social Survey, ABS cat. no. 4714.0.

Community Housing and Infrastructure Needs Survey (CHINS)

The CHINS was designed to assist in the evaluation of policies and programs designed to improve housing and infrastructure services for Aboriginal and Torres Strait Islander peoples living in both discrete communities and in other housing managed by Indigenous organisations. This study used the CHINS survey that was conducted in conjunction with the 2001 Census.

The 2001 CHINS collects information on:

- The current housing stock, dwelling management practices and selected income and expenditure arrangements of Indigenous organisations that provide housing to Aboriginal and Torres Strait Islander peoples; and
- Details of housing and related infrastructure such as water, electricity, sewerage systems, drainage, and rubbish collection and disposal, as well as other facilities such as transport, communication, education, sport and health services, available in discrete Aboriginal and Torres Strait Islander communities.

ARIA++ LORI

ARIA was developed as an index based on the road distance people must travel from a given location to service centres of various sizes. A service centre is an area where people can access goods, services and opportunities for social interaction. The population size of the service centre is used as a proxy for the availability of a range of services. The road distance is used as a proxy for the degree of remoteness from those services. ARIA is based solely on physical geography and is not, by itself, intended to measure other factors such as social isolation, wellbeing or other socioeconomic factors.

The calculation of an ARIA score involves measuring the shortest road distance between a populated locality and categories of service centres. A special adjustment is made for islands when calculating ARIA scores. Service centres are categorised based on the range and type of goods and services that are available. LORI is a set of categories of the ARIA++ scores which allows meaningful analysis of Indigenous health to be undertaken.

C. RSES AND THE ROOT RELATIVE POSTERIOR VARIANCES

C.1 Birth-weight estimates for Western Australia

ATSIC region	*WAACHS direct estimate*	*RSE*	*NHS(I) model estimate*	*Root relative posterior variance*	*NHS(I) random effects model estimate*	*Root relative posterior variance*
Broome	10.7%	23.4%	14.2%	52.1%	n.a.	n.a.
Derby	17.8%	16.9%	13.4%	52.2%	n.a.	n.a.
Geraldton	12.3%	17.9%	10.9%	11.0%	n.a.	n.a.
Kalgoorlie	5.7%	24.6%	10.4%	67.3%	n.a.	n.a.
Kununurra	10.1%	15.8%	13.8%	32.6%	n.a.	n.a.
Narrogin	11.7%	14.5%	10.8%	23.1%	n.a.	n.a.
Perth	10.7%	11.2%	10.8%	25.9%	n.a.	n.a.
South Hedland	12.0%	19.2%	11.0%	36.4%	n.a.	n.a.
Warburton	13.0%	43.1%	12.6%	27.0%	n.a.	n.a.

C.2 Self-harm estimates for Western Australia

ATSIC region	*WAACHS direct estimate*	*RSE*	*NHS(I) model estimate*	*Root relative posterior variance*	*NHS(I) random effects model estimate*	*Root relative posterior variance*
Broome	26.4%	20.1%	16.5%	47.9%	17.1%	47.4%
Derby	15.3%	38.6%	7.3%	53.4%	6.1%	67.2%
Geraldton	8.6%	27.9%	7.2%	38.9%	7.4%	43.2%
Kalgoorlie	6.3%	25.4%	3.1%	61.3%	2.8%	64.3%
Kununurra	5.8%	20.7%	6.2%	71.0%	5.2%	80.8%
Narrogin	9.9%	20.2%	7.2%	36.1%	7.0%	42.9%
Perth	12.8%	10.9%	16.6%	28.3%	16.1%	31.1%
South Hedland	8.2%	28.1%	6.5%	52.3%	8.3%	65.1%
Warburton	3.1%	64.5%	8.0%	47.5%	6.9%	59.4%

C.3 Tropical ear estimates for Western Australia

ATSIC region	*WAACHS direct estimate*	*RSE*	*NHS(I) model estimate*	*Root relative posterior variance*	*NHS(I) random effects model estimate*	*Root relative posterior variance*
Broome	24.1%	12.0%	25.8%	32.2%	26.0%	63.5%
Derby	28.0%	8.2%	27.6%	38.8%	28.0%	98.6%
Geraldton	23.6%	10.2%	19.9%	14.6%	19.6%	17.3%
Kalgoorlie	21.5%	13.5%	25.6%	59.0%	27.0%	100.4%
Kununurra	24.6%	9.8%	28.3%	38.5%	28.9%	93.1%
Narrogin	18.0%	8.9%	20.6%	18.9%	20.0%	25.5%
Perth	18.4%	6.5%	18.1%	17.7%	18.3%	19.7%
South Hedland	25.7%	12.4%	21.6%	29.6%	22.5%	37.8%
Warburton	29.9%	11.0%	26.8%	35.1%	27.3%	84.2%

D. PROGRESS SINCE THE JUNE 2005 MAC MEETING

A number of issues were raised at the MAC meeting, in particular the validity of the assumption that there is no jurisdiction effect so that models developed in Western Australia can reasonably be applied to Queensland and the Northern Territory. It was also suggested that we should investigate the use of multilevel modelling. It was agreed that the key assumptions need to be clearly articulated along with the criteria for assessing whether the assumptions hold or not. There was general support for investigating synthetic methods such as these so long as the quality associated with the methods was understood and on the basis that the key assumptions hold.

Following this meeting, the project team focused on testing the following three key assumptions:

- models with reasonable explanatory power can be developed from the WAACHS, for Western Australian ATSIC regions.
- the predictor variables drawn from the WAACHS are available for Queensland and the Northern Territory in a comparable form from a national data set, i.e. they measure the same concept and were collected using similar questions.
- relationships identified in the WAACHS data for Western Australia will be similar to those in Queensland and the Northern Territory.

The validity and quality of all modelled estimates depend critically on these assumptions and this needs to be well understood by users. To test the third assumption the project team modelled the results by interacting flags for each jurisdiction with each of the explanatory variables. The joint significance of the coefficients of the interaction terms could then be statistically tested. A number of models were developed but most of the variables in the models were not significant and hence we were unable to test whether the strength and the direction of the relationships are consistent across jurisdictions.

In response to the comments from the MAC members, the project team fully articulated the diagnostics that will be used to demonstrate the strength of the model fit. These include:

- goodness of fit statistics (such the Hosmer and Lemeshow test)
- statistical significance of the estimated coefficients for each predictor variable in the model
- predictive power of the model in terms of the mean square error, tests against direct estimates for bias and additivity to higher level aggregates
- plausibility of the predictor variables in terms of direction and magnitude of their coefficients

- plausibility of the predicted indicators in terms of how well their spread across regions is consistent with local knowledge.

The following quality criteria were applied to each of the test variables:

- Can a valid model be fitted?
- Are comparable predictor variables available in all jurisdictions?
- Are model estimates affected by jurisdiction?
- Are predictions from the model's plausible?

A series of models, including random effects and multi-level models, were developed and assessed against these criteria. After assessing the variables in the models, the 2001 Census was used as the primary data source and supplemented with contextual variables from Statistical Subdivision, for example percentage of Indigenous people who smoke. This increased the level of data available for modelling and improved the accuracy of the synthetic estimates.

A status report and detailed technical paper will be available early 2007. Based on our investigations we concluded that the evidence is insufficient to prove or disprove a jurisdiction effect and without this conclusive evidence we are unable to state that a key assumption underpinning these synthetic estimates holds. Hence, we have concluded that given the current national datasets and variables available it is not feasible to derive synthetic estimates for Queensland and the Northern Territory based on the WAACHS.

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