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Author/s:

Foreman, J;Keel, S;Dunn, R;van Wijngaarden, P;Taylor, HR;Dirani, M

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Sampling methodology and site selection in the National Eye Health Survey (NEHS): an Australian population-based prevalence study

Joshua Foreman BSc(Hons),^{1,2} Stuart Keel PhD,¹ Ross Dunn BAppSc(AppChem),³
Peter van Wijngaarden FRANZCO,^{1,2} Hugh R Taylor FRANZCO⁴ and Mohamed Dirani
PhD^{1,2}

¹Centre for Eye Research Australia, Royal Victorian Eye & Ear Hospital, Melbourne, Australia, ²Ophthalmology, University of Melbourne, Department of Surgery, Melbourne, Australia

³Clinical Epidemiology and Biostatistics Unit, Murdoch Children's Research Institute, The Royal Children's Hospital, Melbourne, Australia

⁴Indigenous Eye Health Unit, Melbourne School of Population and Global Health, the University of Melbourne, Melbourne, Australia

Correspondence: Dr Stuart Keel, Level one, Centre for Eye Research Australia, 32 Gisborne Street, East Melbourne, Victoria, Australia 3002

Email: stuart.keel@unimelb.edu.au

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ABSTRACT

Background: To present the sampling methodology and selected testing sites of the National Eye Health Survey (NEHS); a cross-sectional population-based survey that aimed to determine the prevalence of vision impairment and blindness in Australia.

Design: Cross-sectional survey.

Participants: Indigenous Australians aged 40 years and older and non-Indigenous Australians aged 50 years and older residing in all levels of geographic remoteness in Australia.

Methods: Using multi-stage, random-cluster sampling, 30 geographic areas were selected to provide a sample of 3000 non-Indigenous Australians and 1400 Indigenous Australians. Site selection involved; 1) Selecting Statistical Area-Level 2 (SA2) sites, stratified by remoteness; 2) Selecting Statistical Area-Level 1 (SA1) sites within SA2 sites to provide targeted samples; 3) Grouping of target SA1 sites with contiguous SA1s or replacing SA1s to provide sufficient samples. Participants were recruited using a door-to-door approach.

Main outcome measures: Sites selected and participants sampled in the National Eye Health Survey.

Results: Thirty sites were generated, including; 12 Major City, 6 Inner Regional, 6 Outer Regional, 4 Remote, and 2 Very Remote sites within 5 States and one Territory. 3098 non-Indigenous participants and 1738 Indigenous participants were recruited. Selection of SA1s overestimated the number of eligible residents in all sites. 20% (6/30) of SA1s were situated in non-residential bushland, while 26.67% (8/30) of SA1 populations had low eligibility or accessibility, requiring replacement with contiguous SA1s.

Conclusions: Representative samples of Indigenous and non-Indigenous

Australians were selected, recruited and tested, providing the first national data on the prevalence of vision impairment and blindness in Australia.

Keywords: national survey, random-cluster sampling, population health

INTRODUCTION

The World Health Organisation (WHO) estimated that in 2012, 285 million people had vision impairment (VI) globally, of which 39 million were blind.¹ The 'Universal Eye Health: a Global Action Plan 2014-2019' was endorsed at the 66th World Health Assembly (May, 2013) to reduce the prevalence of avoidable blindness globally by 25% by 2019.² The Global Action Plan emphasised the need for generating population-based prevalence data for VI and blindness at a national level to inform future strategies aiming to reduce vision loss in each country, including Australia. National population-based surveys differ in their sampling methodologies. While simple random sampling theoretically provides the most precise and representative sample, the time and resources required render this method unfeasible in most instances. For this reason, multi-stage random-cluster sampling is considered to be the most practical method when conducting population-based surveys to produce representative data at a national level.³ However, not all population-based eye studies conducted locally or internationally adhere to all aspects of this methodology. These shortcomings include a lack of national coverage, absence of stratification and random sampling and the use of sub-optimal cluster selection. This is largely due to logistical constraints as well as a lack of population and geographic data. A recent review⁴ of 53 studies from 39 countries that investigated the prevalence of VI and blindness found that studies for only 13 countries had nationwide coverage.⁵⁻¹⁷ There is a paucity of nationwide prevalence studies in VI and blindness in the world, with only six national studies being completed and published since 2012.¹⁸⁻²² Furthermore, many studies such as those using the Rapid Assessment of Avoidable

Blindness protocol²³ have not stratified their selected populations on the basis of characteristics that may affect the prevalence of VI, or have not randomly selected their samples,²⁴ and this contributes to a lack of consistency between surveys globally.

No studies in Australia have estimated the prevalence of VI and blindness in both Indigenous and non-Indigenous Australians using a nationally representative methodology. Two landmark studies, the Melbourne Visual Impairment Project (VIP)²⁵ and the Blue Mountains Eye Study (BMES)²⁴ conducted in the early 1990s, provided excellent insights into the prevalence of VI and blindness. However, the generalisability of both studies were limited due to their sampling methods. On one hand, the Melbourne VIP obtained its sample using cluster-stratified random sampling, however the site selection was not multi-staged.²⁶ This study included 4 rural sites, 9 urban sites from the general population and nursing homes in one State (Victoria), thus limiting the extent to which findings could be extrapolated to a national level. On the other hand, The BMES used a convenience sample, selecting two postcodes in the west of Sydney, (New South Wales) due to the older demographic in the area.²⁷ The National Indigenous Eye Health Survey (NIEHS), conducted in 2008, utilised a highly robust stratified multi-stage random-cluster approach, but while this study included a small convenience sample of non-Indigenous Australians, its focus was on the Indigenous population.²⁸ Despite these limitations, these studies have remained the reference studies for the prevalence of VI and blindness in Australia until now.

The National Eye Health Survey (NEHS) was conducted in order to provide national estimates of VI and blindness in Australia. The NEHS implemented a multistage random cluster sampling methodology, with cluster selection stratified by geographic remoteness, to generate representative prevalence data on VI and blindness. This paper describes the sampling and site selection process in the NEHS.

METHODS

Ethics approval

The protocol for this study was approved by the Royal Victorian Eye and Ear Hospital Human Research Ethics Committee (HREC-14/1199H). Additional ethics approvals were obtained from the Aboriginal Health and Medical Research Council of New South Wales (HREC-1079/15), the Menzies School of Health Research (HREC-2015-2360), the Aboriginal Health Council of Western Australia (HREC-622) and the Aboriginal Health Council of South Australia (HREC-04-15-604). This research was conducted in accordance with the Declaration of Helsinki.

Sampling

The NEHS aimed to recruit and examine a total of 4400 participants. Selection of sites utilised Census 2011 data collected by the Australian Bureau of Statistics (ABS). Using multi-stage random cluster sampling, 30 randomly selected sites containing approximately 100 non-Indigenous Australians aged 50 years and over, and 50 Indigenous Australians aged 40 years and over, stratified by remoteness were selected. The age criterion of 50 years and over for non-Indigenous participants was chosen to reflect the age group suggested by the WHA Global Action Plan for national prevalence surveys.² The younger age inclusion criterion for Indigenous participants was chosen due to the earlier onset and more rapid progression of major eye diseases and diabetes in Indigenous Australians.²⁹ Participants were considered to be Indigenous Australians if they reported that they were: A) Aboriginal; B) Torres Strait Islander; or C) Aboriginal and Torres Strait Islander.

Sample size calculation

The non-Indigenous sample size calculation was based on previous data on the prevalence of VI from the Melbourne VIP. The sample size was calculated as 1552

with an upper limit of 1799 based on a margin of error of 1.1% using the sample size calculation formula $n = [z^2 \times p \times (1-p)]/e^2$ where $p=0.0515$, $Z=1.96$ and $e=0.011$. Assuming a design effect of 1.5 that adjusts for the inter-class correlations between participants within clusters and a 20% non-response rate, the required sample size was 2794 (upper limit 3238). Using the same calculation with a margin of error of 2%, and assuming a similar prevalence to the NIEHS, the Indigenous sample size was calculated to be 1368 (approximately 1400). Therefore, the combined sample size required for this study was 4400. Assuming a cluster size of 150 per sampling site, 30 sites were required.

Site selection

Setting the geographical sampling unit for the first sampling stage

ABS Census 2011 data were used to inform study site selection. The ABS used a geographical classification system, the Australian Statistical Geography Standard (ASGS) in the 2011 Census to divide Australia into discrete geographical structures or Statistical Areas (SA).³⁰ SAs are categorised at different levels, with SA4, the largest SA unit, composed of multiple smaller SA3s, which in turn are composed of multiple smaller SA2s that are made up of multiple smaller SA1s. The SA2 was the initial geographic unit for study site sampling in the NEHS.

Constraining the sampling pool

A set of constraints was added to the list of 2097 SA2 sites across Australia. To be eligible for inclusion in the site selection pool, SA2s were required to contain at least 10 non-Indigenous Australians aged 50 and older, and either 6 or 10 Indigenous Australians aged 40 years and older in urban and rural SA2s, respectively. This limit was chosen as it was the most suitable criterion to balance the need for a sufficient number of SA2s in the sampling pool, while attempting to include sites with

appreciable population densities. Consequently, 1,842 SA2s, containing a total population of 19,499,171 residents were available for site selection.

Stratifying by Remoteness

The ABS assigned a value from 0.00 to 15.00 to each SA2, denoting the level of remoteness according to the Accessibility/Remoteness Index of Australia Plus (ARIA+) system, with ARIA+ categories including; Highly Accessible (ARIA+ range: 0.00-0.2), Accessible (ARIA+ range: >0.20-2.40), Moderately Accessible (ARIA+ range: >2.40-5.92), Remote (ARIA+ range: >5.92-10.53) and Very Remote (ARIA+ range: >10.53-15.00). ARIA+ superseded the Remoteness Area (RA) classification system used by the ABS that classified SAs according to discrete numbers of 1 to 5, corresponding to Major City, Inner Regional, Outer Regional, Remote and Very Remote. The ARIA+ groups were converted to the discrete RA groups for NEHS site selection according to Table 1 for ease of interpretation. Twelve Major City sites, 6 Inner Regional sites, 6 Outer Regional sites, 4 Remote sites and 2 Very Remote sites were chosen to correspond approximately to the population distributions within each of the RAs. Back-up sites were selected for each RA, to be used if primary sites were unsuitable due to logistical or administrative reasons.

To stratify NEHS site selection by remoteness, all 1,842 SA2s were grouped into their RA categories and ranked by their ARIA+ scores in ascending order (Table 2). The total progressive population in each RA was divided by the number of sites required in each RA to separate the RA into discrete blocks of equal population size (block size) to ensure that sites were selected from across the whole ARIA+ spectrum.

Selecting the Sites

For each stratified RA, the random number function in Microsoft Excel (32-bit Version 14.0.7.128.5000) was used to create a 'seed value' which was multiplied by

the RA block size to provide a unique population 'selection value' for each RA. The selection value was used to select the same number in the cumulative population in all blocks within the RA, and the SA2 in which that individual in the population was located, was selected as the survey site for that block. This was repeated for all RAs to provide 30 primary sites and 10 backup sites.

Setting the geographical sampling unit for the second sampling stage

SA2s contain non-Indigenous populations exceeding the cluster size required for the NEHS. Therefore, the second stage of sampling required the selection of a sub-cluster within each SA2. SA1 population sizes correspond approximately to the required cluster size in the survey, however their population sizes are variable, and selection of a single SA1 may have produced highly variable cluster sizes. SA2s were therefore divided into blocks of one or more SA1s such that the blocks would be as close as possible to the required cluster size whilst also allowing each block in the SA2 to contain a similar sized non-Indigenous target population. The random number function was then used to select a cluster for targeted recruitment. Sampled clusters consisted of one to three SA1s. Some SA1s within a selected SA2 were not contiguous or did not have similar population sizes or could not be divided into clusters with the required number of eligible residents within a reasonable block size. In these cases, selection of the SA1 had to reflect the practicalities of door-to-door recruitment within the time and budget constraints of this study, and SA1s were selected to accommodate these considerations. The geographical boundary of each site was then overlaid on a corresponding image from Google Maps to provide a street level map to be used for door-to-door recruitment. SA1 sites were not used for sampling of the target Indigenous population because Indigenous populations are sparse and SA1 populations rarely contain sufficient Indigenous residents. Depending on the target Indigenous population size at each selected site, the SA2 or SA3-level area was used to obtain the required sampling population.

Door-to-door enumeration and site adjustments

Door-to-door knocking

Recruiters went to each accessible residence in the recruitment site, and delivered an information pamphlet outlining the study in each mailbox with a message that recruiters would be returning within 48 hours. Recruiters then went door-to-door to enumerate eligible residents and invite them to participate using a standardised script. In cases where residents were absent at the first attempt at recruitment, recruiters returned within 2 days to re-attempt contact. Residents who were not present following two attempts were deemed non-contactable.

Site modifications for non-Indigenous clusters

A systematic approach was implemented to compensate for disparities between the ABS Census data for non-Indigenous residents and population sizes enumerated by survey recruiters. Disparities were likely to occur as 1) some residents were expected to be absent; 2) not all homes would be accessible; 3) sampling was conducted based on Census data from 2011, and eligibility of the constituent populations was likely to have changed during this period; 4) population density would be prohibitively low in some sites, including in areas comprised almost entirely of farmland or bushland.

SA1s with low eligibility rates, such as those in which estates were recently built for young families, or SA1s located in bushland with low population density, were replaced with the closest SA1 with an acceptable population density. SA1s identified through door-to-door enumeration as having insufficient sample sizes, but with permissive population densities and adequate eligibility rates, were merged with the largest contiguous SA1. Progressively smaller contiguous SA1s were sampled to complete recruitment in the allocated timeframe of 3 to 5 days per study location. The ARIA+ score of the SA2 in which all site extensions or replacements occurred

were always within the same RA classification as the original site. All residences visited by recruiters outside of the randomly-selected SA1 were documented on an online cloud-based database and overlaid onto a map of their SA1 boundaries to allow adjusted sampling weights to be derived.

Site modifications for Indigenous clusters

The eligible target Indigenous population in the list of available SA2s was expected to comprise only 2.27% of the total eligible population (Table 2). However, the sample size calculation required a 31.81% composition (1400/4400). Therefore it was expected that SA1 clusters and their surrounding areas would not contain sufficiently large Indigenous populations. In addition, ethical approval from 5 HRECs and community endorsements from 32 state-level or community organisations were required before recruiters were able to engage Indigenous communities. The nearest Indigenous communities to the sampled SA1 were used for recruitment of Indigenous participants. In cases where community consultations were unsuccessful, and NEHS staff were unable to gain access to Indigenous communities in the randomly selected survey site, a backup site was used.

RESULTS

Randomly-sampled NEHS survey sites

A total of 30 core sites and 10 backup sites across five states and one territory were selected for the NEHS using multistage random cluster sampling (Table 3). Sites were distributed across RAs as follows; twelve core sites and 4 back-up sites from the Major City RA, 6 core sites and 2 back-up sites from each of the Inner Regional and Outer Regional RAs, 4 core sites and 1 back-up site from the Remote RA, and 2 core sites and 1 back-up site from the Very Remote RA. The ARIA+ distributions for the core SA2 sites in each RA were: Major Cities: 0.00-0.13; Inner Regional: 0.37-

2.28; Outer Regional: 2.55-5.15; Remote: 6.00-9.00; and Very Remote: 13.28-14.33, indicating that sites were distributed evenly across the ARIA+ spectrum

Modified non-Indigenous clusters

Random selection of SA1 clusters generated 24 sites that were suitable for door-to-door recruitment. However, 6 SA1s (20%) were located in rural areas containing farmland, bushland or large bodies of water, with very low population densities. Sites affected were Goulburn (NSW), Tomerong-Wandandian-Woollamia (NSW), Ulladulla Region (NSW), Rockhampton Region-East (QLD), Eden (NSW) and York Peninsula-South (SA). Due to logistical constraints, door-to-door knocking in these areas was deemed unfeasible, and the nearest SA1 with a suitable population density and the same RA classification was selected for recruitment.

Of the 24 SA1 sites suitable for door-to-door recruitment, 8 (33.33%) were identified by recruiters as having low eligibility or contactability rates. The randomly-selected SA1s in the sites of Springfield (QLD), Parklea-Kellyville Ridge (NSW), Elderslie-Harrington Park (NSW), and Wodonga (VIC), were all situated within newly constructed estates, inhabited predominantly by young families who did not fit the inclusion criteria. South Hedland (WA), established as a mining town, had a particularly low eligibility rate as the town's population was comprised almost entirely of young workers operating the mines. The SA1 in Banana (QLD) had a high rate of absent residents. In Wagaman (NT), a high proportion of residents were inaccessible due to secured locked gates. For all 8 sites, eligible residents were enumerated from adjacent SA1s or SA2s.

Modified Indigenous clusters

Back-up sites

A total of five backup sites were used in the NEHS (Table 4). Of these, two were utilised because Indigenous communities in the core sites of Warilla (NSW) and

Mount Isa (QLD) declined to participate. NEHS project leads were advised that the Derby-West Kimberley (WA) site would require lengthy community consultation for ethical approval, and due to time constraints, a backup site was used. Two Major City sites selected in NSW had small Indigenous populations, and backup sites were used only for Indigenous sampling and recruitment, while the core sites were used for non-Indigenous sampling. Figure 2 displays all core sites sampled in the NEHS, including those that were unsuitable for recruitment, as well as the back-up sites used.

Proximity of Indigenous and non-Indigenous clusters

Due to the sparseness of Australia's Indigenous population, all randomly-selected SA1s contained insufficient numbers of eligible Indigenous residents. In these instances, the nearest Indigenous communities were selected as recruitment sites under the guidance of local Indigenous organisations at each site. Distances between randomly-selected SA1s and areas where Indigenous participants were recruited ranged from 1 km (South Hedland) to 401km (Exmouth, with the nearest Indigenous population in Onslow).

Study participants

A total of 23,235 residences were visited across all 30 sites from March 11th 2015 to April 18th 2016, of which 11,883 had contactable residents. A total of 6,760 residents were enumerated as eligible to participate in the survey. Of these, 5764 agreed to participate (positive response rate of 85.27%) and 4836 (3098 non-Indigenous and 1738 Indigenous) attended testing centres and were examined (examination rate of 71.5%). Of the 3098 non-Indigenous participants recruited, 1253 (40.4%) resided in Major Cities, 636 (20.5%) in Inner Regional areas, 625 (20.2%) in Outer Regional areas, 367 (11.8%) in Remote areas, and 217 (7.0%) in Very Remote areas.

Indigenous participants were distributed across the Remoteness Areas as follows:

741 (42.6%) in Major Cities, 315 (18.1%) in Inner Regional, 405 (23.3%) in Outer Regional, 181 (10.4%) in Remote and 96 (5.5%) in Very Remote sites.

DISCUSSION

This paper describes the sampling methodology in the NEHS and provides details of the selected recruitment sites. The NEHS is the first cross-sectional population-based survey to provide nationally-representative data on the prevalence and main causes of VI and blindness in Australia. Multistage random-cluster sampling was used to select targeted SA1 recruitment sites, stratified by remoteness, to provide a sample of 3000 non-Indigenous Australians aged 50 years or older, and 1400 Indigenous Australians aged 40 years and older. A total of 30 core sites and 10 backup sites were sampled across the ARIA+ spectrum in five States and one Territory in Australia. Systematic and consistent site modifications were made where ABS data did not correspond to populations enumerated by survey recruiters, or where Indigenous populations were too small in number or inaccessible. Trained recruiters successfully recruited 3098 non-Indigenous and 1738 Indigenous participants through a door-to-door approach, providing a high examination rate of 71.5%.

Nationwide representation

The NEHS was the first population-based eye study in Australia that achieved extensive geographic coverage of the national population, with sites being selected from multiple states and across all levels of remoteness. Previously, population-based surveys investigating the prevalence of VI and blindness in Australia did not generate nationally-representative samples as they surveyed residents in only one state each.^{24, 26} Many surveys conducted in other countries have also not provided nationally-representative estimates of VI and blindness as they have collected samples from sub-national geographic areas, such as provinces/states or districts,³¹⁻

³⁸ or collected samples at a national scale but with insufficient sample sizes.³⁹ While many of these studies have not made claims of national representativeness,³¹⁻³⁴ a considerable number have extrapolated their findings to national populations.³⁵⁻⁴⁰ This introduces the risk of uncontrolled population differences between sub-nationally sampled populations and the wider national populations they intend to represent. By including 1,842 SA2s from almost all regions within all states/territories in the sampling pool, the NEHS achieved national representation that compared favourably with other nationwide surveys.^{41, 42}

Stratifying by remoteness

A distinguishing feature of the NEHS sampling methodology was the process by which remoteness was incorporated into the study design. The NEHS employed a robust procedure for stratifying sites by remoteness, ensuring that participants from all levels of remoteness in Australia were selected in proportions that reflected their distributions in the wider population. This is important as the prevalence of vision loss may vary between areas of different remoteness, due to a lower availability of eye healthcare services in more remote areas.⁴³ While other studies have implemented some form of remoteness stratification,²⁸ most have considered remoteness as an urban-rural dichotomy.^{15, 19, 21} The majority of studies, both in Australia and globally, have not reported stratifying by remoteness at all,^{18, 39, 44-47} have only controlled for remoteness through design effect calculations, or retrospectively adjusted for remoteness during analysis.^{14, 20, 41} The ARIA+ system used in the NEHS assigns a remoteness score to all SAs as a function of road distance to the nearest major service centre (including health service centres). Selecting sites from across the ARIA+ spectrum significantly reduced the risk of overall prevalence data being affected by bias associated with confounding effects of remoteness. It should be noted that random selection resulted in the majority of sites being situated in close proximity to the coast. Despite the NIEHS having

reported no significant differences in the prevalence of vision impairment across remoteness strata, both inland and coastally, the Central Australian Ocular Health Study suggested that Indigenous Australians residing inland may suffer from particular high rates of eye disease such as trachoma.⁴⁸ Estimates of the prevalence of vision impairment for Australians residing in the coastal Very Remote sites in the NEHS may therefore be somewhat limited in their generalisability to inland Very Remote communities.

Multistage random cluster selection

While simple random sampling is always preferred due to the low variance and low bias in the resulting sample, the multistage random cluster method is ideal for national surveys given the cost, time and feasibility issues. Multistage sampling is associated with an increase in sample variance due to interclass correlations and the design effect, but the current study compensated for this in the sample size calculation. The remaining small increase in variance was outweighed by the reduction in sample size, and cost and time requirements, allowing results to be delivered timeously to inform policies in the line with the Global Action Plan.²

Site modifications

Merging with contiguous SA1s

Merging contiguous SA1s with randomly-selected SA1s was conducted in a systematic and consistent manner, and proved indispensable in sample enumeration. Sample size calculations presumed a non-response rate of 20%, meaning that of all eligible residents enumerated in the 2011 Census, only 20% would not be recruited to the survey due to both absenteeism and declining to participate. While recruiters achieved a very low decline rate, non-eligibility and non-contactability were higher than expected. Consequently, as measured against the outdated ABS data, absolute recruitment rates were low. As only a 20% non-response was accounted for in determining required cluster sizes, the margin of error was insufficient to accommodate for unpredictable population parameters. Therefore, to ensure the recruitment of a sample size large enough to provide adequate statistical power, it was necessary to expand sites, introducing an element of selection bias. Future population based surveys in Australia would benefit from using a larger cluster size than a single SA1, containing larger than required populations to allow for higher than expected non-response rates. Comparatively, Indigenous areas of up to four times the required sample were selected in the NIEHS.⁴⁹ Although this may not eliminate the problem of non-response bias, pre-emptively avoiding the need for recruiters to non-randomly select contiguous sites would remove selection bias. Furthermore, the fact that the ASGS data used in NEHS site selection was outdated presents a risk of inaccuracy as population changes may have occurred since the completion of the Census in 2011. Selecting sites based on more current Census data may be beneficial and future investigators may wish to conduct surveys soon after Census to maximise the accuracy of reference Census data.

Replacement of sites with low population density

Australia has the 7th lowest population density of any country, and the majority of its land is either uninhabited or contains sparse communities.⁵⁰ The exclusion of 255

low-density SA2s (12% of all SA2s) from the sampling frame attempted to generate a list of sites for which door-to-door recruitment was feasible. This process is reflected in previous national survey research in Australia.⁵¹ Despite these constraints, the current study randomly sampled 6 sites with populations that were too inaccessible or sparse for recruitment. Replacement of these sites with accessible populations was imperative to ensure the completion of the survey within a specified timeframe.

Oversampling of Indigenous participants

Indigenous Australians have been shown to have poorer eye health than their non-Indigenous counterparts.⁵² Considering this, determining the prevalence of VI and blindness in Indigenous Australians was essential. However, as Indigenous Australians comprised only 2.27% of the target population, if they were sampled in this proportion, an insufficient sample size would have resulted. The survey was designed to provide a sample of 1400 Indigenous participants, (31.81% of the total sample), resulting in significant oversampling. The sampling of Indigenous participants was similar to the NIEHS in terms of sample size and remoteness stratification. Therefore, the results of the NEHS can be directly compared to those of the NIEHS, providing follow-up data to ascertain the effectiveness of interventions implemented since that study was completed.

Consequences for sampling weights

As the NEHS intended to report the sampling-adjusted prevalence of VI and blindness, sampling weights from each site were required. However, post-sampling site adjustments resulted in the following consequences; 1) the population of the primary randomly-selected SA1 reported by the ABS was insufficient to derive sampling weights, as contiguous areas with additional residents were merged with the SA1; 2) due to the differences between the Census and NEHS population

numbers, ABS population data could not be used to calculate absolute response rates; 3) as some sites required replacement, the Census data pertaining to the original randomly-selected SA1 could not be used. Consequently, the use of SA1-level population data provided by the 2011 Census would have significantly under-represented or misrepresented the size of the actual population visited, enumerated and recruited. This was effectively dealt with by storing all addresses visited by recruiters on a database, and overlaying them on maps with their SA boundaries. This allowed for more accurate sampling weights calculation, thereby providing a more reliable basis from which to derive sampling-adjusted prevalence.

In conclusion, the sampling methodology in the NEHS was comprehensive and used a well-designed, multistage, random-cluster sampling of 30 sites stratified by levels of remoteness across Australia. Minor adjustments were made to the sampling protocol to overcome challenges resulting from Australia's geographic and population structures. Representative samples consisting of 3098 non-Indigenous Australians and 1738 Indigenous Australians were recruited and tested, providing the first national data on the prevalence of VI and blindness in Australia.

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TABLES

Table 1: Conversion of Accessibility/Remoteness Index of Australia classifications to Remoteness Areas

ARIA+ ¹ category	ARIA+ range	Corresponding Remoteness Area (RA) ²	Corresponding RA value
Highly Accessible	0 – 0.2	Major City	1
Accessible	> 0.2 – 2.4	Inner Regional	2
Moderately Accessible	> 2.4 – 5.92	Outer Regional	3
Remote	> 5.92 - 10.53	Remote	4
Very Remote	> 10.53 – 15.00	Very Remote	5

¹Accessibility/Remoteness Index of Australia: The ABS endorsed remoteness classification system in the Australian 2011 Census.

²Remoteness Area: The remoteness classification derived from the Australian Standard Geography Classification (ASGC).

Table 2: Distribution of selective SA2 geographical areas across Remoteness Areas

RA ¹	SA2s ²	Tar IP ³	Tar NP ⁴	Tot P ⁵	Block Size	% Pop ⁶
Major City	936	43,567	3,632,398	12,627,075	789,192.19	64.8%
Inner Regional	464	30,706	1,456,275	4,214,982	526,873	21.6%
Outer Regional	322	30,066	688,493	2,042,319	255,290	10.5%
Remote	61	11,383	108,372	395,061	49,383	2.0%
Very Remote	59	21,610	35,110	219,734	27,467	1.1%
Total	1,842			19,499,171		

¹Remoteness Area: The remoteness classification derived from the Australian Standard Geography Classification

(ASGC)

²Statistical Area – Level 2: The geographical unit of site pre-selection

³Target Indigenous population

⁴Target non-Indigenous population

⁵Total population

⁶Percentage of the total population within the total SA2 sampling pool distributed within each Remoteness Area

Table 3: NEHS survey sites: selected Statistical Area Level 2 sites and targeted Statistical Area Level 1 sites

Statistical Area Level 2 (SA2) data								Statistical Area Level 1 (SA1) data				
Site No	SA2 name	State	RA ¹	ARIA+ ²	Area (sqm)	Tar_IP ³	Tar_NP ⁴	SA1	ARIA+	Area (sqm)	Tar_IP	Tar_NP
Corr Sites												
Major Cities												
1	Brighton (Qld)	QLD	1	0.00	6,482,055.16	64	2977	3104209	0.00	281,514.20	0	108
2	Springfield ⁵	QLD	1	0.00	6,673,459.51	32	874	3130301	0.00	590,391.40	0	74
								3130312	0.00	153,075.77	3	38
								Total		743,467.17	3	112
3	Parklea - Kellyville Ridge	NSW	1	0.00	9,877,842.94	36	3169	1131030	0.00	151,915.76	0	88
4	Chipping Norton - Moorebank	NSW	1	0.00	14,490,264.51	48	4851	1152323	0.00	105,418.34	0	121
5	Concord - Mortlake - Cabarita	NSW	1	0.00	6,325,574.85	24	6547	1138341	0.00	115,055.18	0	146
6	Morrongton	VIC	1	0.00	21,089,872.96	32	8830	2138032	0.00	222,147.55	0	113
7	Box Hill - Central	VIC	1	0.00	8,200,350.36	14	4290	2125620	0.00	142,965.52	0	124
8	Craigie - Beldon	WA	1	0.00	7,131,438.77	25	2561	5107009	0.00	175,983.96	0	85
								5107010	0.00	149,986.20	3	72
								Total		325,970.16	3	157
9	Bassendean - Eden Hill - Ashfield	WA	1	0.00	10,344,501.60	91	4514	5104429	0.00	458,631.67	0	209
10	Kalamunda - Maida	WA	1	0.00	28,121,619.03	32	5807	5114002	0.00	280,332.42	0	133

11	Vale - Gooseberry Hill											
	Elldon - Harrington	NSW	1	0.04	21,533,575.05	85	3772	1143410	0.00	289,357.00	3	91
12	Park Warilla	NSW	1	0.13	9,480,393.51	204	7266	1114313	0.13	111,417.98	3	169
	Inner Regional											
13	Lesmurdie - Bickley - Carniel	WA	2	0.37	219,991,095.83	21	3961	5114125	0.00	385,864.17	0	130
14	Goulburn	NSW	2	0.60	64,644,260.60	185	7411	1100125	0.60	9,219,031.38	0	161
15	Vodonga	VIC	2	0.89	278,809,991.40	92	6257	2107405	0.74	957,416.42	0	80
16	Tomerong - Wandandian - Woodlamia	NSW	2	1.14	375,942,158.91	36	1319	1128110	0.94	16,049,084.33	3	162
17	Ulladulla Region	NSW	2	1.88	677,622,119.32	29	2338	1128313	1.51	56,185,123.80	0	117
18	Rockhampton Region - East	QLD	2	2.28	680,170,163.09	35	1094	3121802	2.44	352,559,355.7	6	74
								3121811	1.56	46,332,551.27	6	96
								Total		398,891,906.9	12	170
										8		
	Outer Regional											
19	Whyalla	SA	3	2.55	40,871,748.87	219	6648	4113660	2.54	340,824.86	6	148
20	Geelong	WA	3	2.73	21,228,754.27	328	4161	5121007	2.73	780,992.96	3	168
21	Wagaman	NT	3	3.00	837,954.92	39	438	7102802	3.00	191,459.54	14	80
22	Inverell	NSW	3	3.35	207,668,432.14	203	4049	1119127	3.13	518,178.45	15	154
23	Eden	NSW	3	3.71	94,814,149.25	68	1389	1102303	3.73	3,240,030.21	3	98
								1102310	3.73	1,062,545.60	0	5
								Total		4,302,575.81	3	103

24	Katanning Remote	WA	3	5.14	2,646,877,347.6 4	104	1343	5123013	4.67	558,965.56	10	113
25	Mount Isa	QLD	4	6.00	62,753,989.65	772	3229	3140541	6.00	182,476.25	6	81
								3140544	6.00	237,512.10	19	61
								Total		419,988.35	25	142
26	Daintree	QLD	4	6.27	2,230,932,070.8 7	244	1766	3116407	4.50	505,717.92	6	108
27	Yorke Peninsula - South	SA	4	8.04	2,273,732,701.2 6	13	2099	4112813	7.37	168,306,923.2 5	0	86
28	South Hedland	WA	4	9.00	22,287,425.89	500	956	5122419	9.00	177,083.43	22	27
								5122422	9.00	226,979.06	14	41
								5122424	9.00	121,649.26	12	39
								Total		525,711.75	48	107
	Very Remote											
29	Exmouth	WA	5	13.28	134,986,003,299 .42	87	1172	5119705	11.99	610,061.74	4	133
30	Derry - West Kimberley	WA	5	14.33	110,883,574,518 .85	1067	774	5120624	11.52	1,705,340.29	47	146

Back-up Sites⁶

Major Cities

Backup 1	Willoughby-Castle Cove Northbridge	NSW	1	0.00	10,751,553	18	7803
Backup 2	Seventeen Mile Rocks- Sinnamon Park	QLD	1	0.00	5,389,722	21	2738

Backup 3	Morphett Vale-East	SA	1	0.00	7,684,247	61	4485						
Backup 4	Ashwood-Chadstone	VIC	1	0.00	6,709,546	15	4618						
Inner Regional													
Backup 5	Nambour	QLD	2	0.24	54,024,551	117	6113						
Backup 6	Warrnambool-South	VIC	2	1.56	120,194,041	34	4499						
Outer Regional													
Backup 7	Rosebery-Bellamack	NT	3	3.00	3,176,364	36	336						
Backup 8	Doningo	NSW	3	4.23	1,987,708,554	38	1410	1108707	3.51	333,511.58	0	123	
Remote													
Backup 9	Banahna	QLD	4	6.78	28,527,048,579	92	2668	3119425	3.18	213,021,792.1	0	100	
								3119431	3.04	1,279,878.26	3	79	
								Total		214,301,670.4	3	179	
Very Remote													
Backup 10	Esperance Region	WA	5	11.12	55,408,257,147	22	1147						

1. RA is the Remoteness Area, the remoteness classification derived from the Australian Standard Geography Classification (ASGC).
2. ARIA+ is the Accessibility/Remoteness Index of Australia, the ABS endorsed remoteness classification system in the Australian 2011 Census. Note that the ARIA+ score for the SA2 is the mean ARIA+ score of all constituent SA1s.

3. Tar_IP is the target Indigenous Population, corresponding to the number of Indigenous Australians aged 40 years and older residing in the Statistical Area according to the Australian 2011 Census.
4. Tar_NIP is the target non-Indigenous Population, corresponding to the number of non-Indigenous Australians aged 50 years and older residing in the Statistical Area according to the Australian 2011 Census.
5. All sites with 2 or more rows of SA1 data (Springfield, Craigie-Beldon, Rockhampton Region-East, Eden, Mount Isa and South Hedland) had 2 or more contiguous SAs selected to provide a sufficient population size.
6. Back-up sites were sampled to provide alternative recruitment sites in cases where any of the 30 core sites were unsuitable. Back-up sites used were Morphett Vale (SA) (replaced Indigenous testing in Concord-Mortlake-Cabarita), Banana (QLD) (replaced both Indigenous and non-Indigenous testing in Mount Isa), Seventeen Mile Rocks-Sinnamon Park (QLD) (replaced Warilla) and Esperance Region (WA) (replaced both Indigenous and non-Indigenous testing in Derby-West Kimberley). Recruitment of Indigenous Australians from the randomly-selected Major City site of Parklea-Kellyville Ridge was unachievable, and due to logistical concerns, the

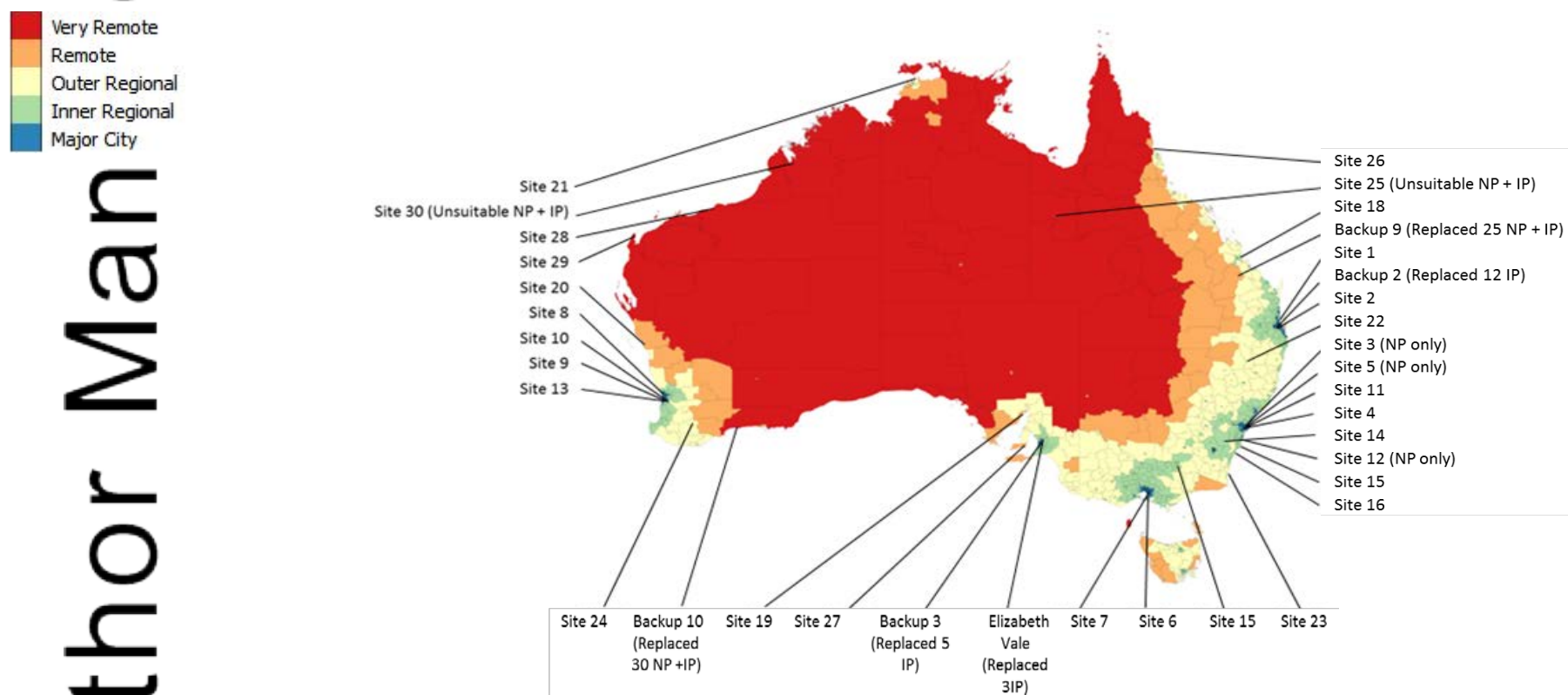
remaining available Major City backup sites could not be utilised. Ashwood-Chadstone (VIC) was identified as containing insufficient eligible Indigenous residents, and communications with local Indigenous organisations in Willoughby-Castle Cove-Northbridge proved difficult. Consequently, Indigenous organisations were consulted to identify an area with comparable sociodemographic characteristics to be used as a backup site. Consequently, the suburb of Elizabeth Vale (SA) replaced Parklea-Kellyville Ridge.

Table 4: Backup sites used in the NEHS

Replaced site	Replacement site	Reason	Indigenous replacement	Non-Indigenous replacement
Conced-Mortlake-Cabarita (NSW)	Morphett Vale (SA)	Indigenous population size too small	Yes	No
Warilla (NSW)	Seventeen Mile Rocks-Sinamon Park (QLD)	Declined by Indigenous organisation	Yes	No
Mount Isa (QLD)	Banana (QLD)	Declined by Indigenous organisation	Yes	Yes
Derby-West Kimberley (WA)	Esperance Region (WA)	Logistical constraints	Yes	Yes
Parklea-Kellyville Ridge (NSW)	Elizabeth Vale (SA)	Indigenous population size too small	Yes	No

FIGURE

Figure 1: Distribution of sampled core survey sites and back-up sites used across Remoteness Areas in the NEHS



NP = Non-Indigenous Population

IP = Indigenous Population

Boundary lines represent Statistical Area – Level 2 boundaries