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Flinders University

An evaluation of the benefits of swimming pools for the hearing and ear health of young Indigenous Australians

A whole of population study across multiple remote Indigenous communities



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Ageing of the
Commonwealth of
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Title: An evaluation of the benefits of swimming pools for the hearing and ear health status of young Indigenous Australians: a whole-of-population study across multiple remote Indigenous communities.

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The extensive work undertaken for this Swimming Pools project involved 6 two week visits each with 13 people to the APY Lands and 6 two or three day visits to Yalata with 5 people in the period 2009-2011. We thank the Anangu children for their wonderful cooperation and infectious enthusiasm for our work with them. We thank their families and all 11 communities for agreeing to participate in the project.

In all schools we were well supported by the principals, teachers and administrative staff. We also thank and acknowledge the unflagging interest and support of the Coordinating Principal, Mr. Martyn Burne, and staff at the Anangu Education Service (AES) office in Ernabella.

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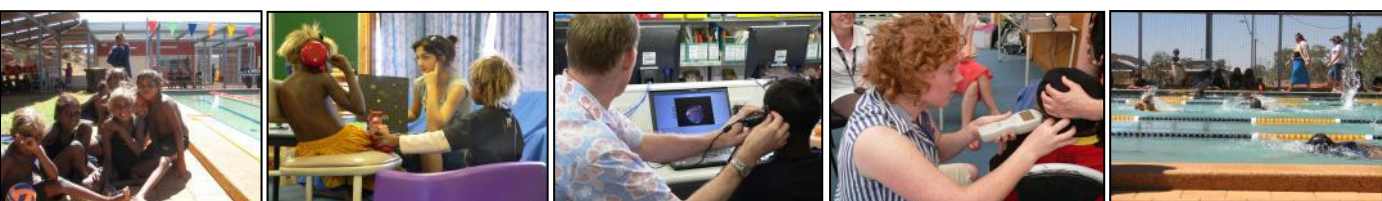
Forty eight Flinders University students participated in the collection of the data on the 6 visits to the APY Lands. The scope of the work was only possible because of their energy and competency. We also had wonderful expert help on all visits to the APY Lands and to Yalata from a large number of audiology and medical colleagues.

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Front cover artwork: Elaine & Venita Woods 'Minyma Kutjara' (2011) detail (with permission).





Executive Summary

Research into strategies for reducing the prevalence of middle ear disease (otitis media) and related hearing loss in Indigenous children is vitally important because of the extraordinarily high prevalence of otitis media and disabling levels of hearing loss experienced by young Indigenous Australians in remote areas. In 2008 the Commonwealth Department of Health and Ageing provided funding for Flinders University and its collaborating partner, the Anangu Education Service of the SA Dept. of Education and Child Development, to investigate whether the use of swimming pools (SP) by school-age Indigenous children in remote communities results in the reduction and possible prevention of conductive hearing loss related to otitis media in these children. The study was triggered by the much publicised findings of Western Australian researchers that the provision of swimming pools in two Indigenous communities in remote semi-arid Western Australia significantly reduced skin and some ear disease in children.

The claims of the WA study appeared to be good news in the bleak area of chronic infections in Indigenous children. However the limitations of the WA study, principally the absence of control communities, small participation numbers and short duration, signalled the need for further investigation of the results. Flinders University audiology and medical staff were well placed to address this problem on a larger scale. Six years of prior work on the ear health and hearing of Anangu school-age children in 9 communities on the remote APY Lands of north-western SA and in Yalata community in the far west of SA showed appallingly high levels of hearing loss and perforation of the eardrum caused by otitis media. The Flinders University work was the catalyst for educational measures which were put in place to support the hearing needs of many of the Anangu students. However, primary health care and public health strategies targeting middle ear disease remain limited.

By 2007 there were 4 new, Commonwealth funded, saltwater chlorinated swimming pools, 3 on the APY Lands and 1 in Yalata. These provided an opportunity for the more definitive study, described here, of the benefits of swimming pools for hearing and ear health. The Swimming Pool project has had large participant numbers, communities without swimming pools as control communities for direct comparison and a longitudinal time frame of 3 years.

Between 2009-2011 eight hundred and thirteen Anangu children and adolescents were assessed between 1 and 6 times in their schools during biannual visits (a total of 2107 assessments). At each visit multiple measures of hearing and ear health were recorded and

each child was assessed by an ear, nose and throat specialist. Forty five percent of the children were assessed on at least 3 occasions.

The outcomes of this research demonstrate that on all clinical measures (audiological and medical) there is no significant effect of swimming pools on ear health or hearing. Additionally there is no evidence that access to swimming pools results in improved school attendance.

Data on occasions of pool usage by individual children were not available. However a surrogate of this, school attendance, was used as a quantitative measure for children's exposure to pools in Pool communities. As explained in the Report we do not consider that the lack of data about individual children's usage of pools has compromised the findings of this research.

In conclusion the authors are of the opinion that there is no evidence of the efficacy of saltwater chlorinated swimming pools for improvement of ear health or hearing in children in remote arid zone indigenous communities.

This study's strengths have been strong local collaboration; excellent infrastructure, including technology and appropriately trained personnel with expertise and experience in research into ear health and hearing in Indigenous communities and a very large longitudinal sample. Accordingly the results are robust and the study was not subject to most of the significant problems that researchers commonly find when collecting data in remote Indigenous communities. Our prior work in the Anangu schools had established familiarity with and trust and respect from the Anangu communities which resulted in their strong endorsement and support for this Swimming Pool study.





Conclusions and Recommendations

Conclusion 1

There was no significant difference between children in Pool or Non-Pool communities in their hearing screening results (pass/fail rates), the prevalence of abnormal tympanograms or the prevalence of eardrum perforations (wet or dry). This finding demonstrates that access to and use of a swimming pool does not result in improvement in any of the measured indices of hearing or ear health.

Comment: The low success rate or failure of a variety of strategies and treatments in recent years in effecting reduction in the prevalence, incidence and/or severity of otitis media in remote Indigenous children attests to the complex nature of otitis media as a chronic infection in Indigenous children. The most recent Recommendations for Clinical Care Guidelines on Otitis Media describe it as “a complex condition” and “best regarded as a spectrum of disease.” Referring to Indigenous children in rural and remote Indigenous communities, the authors stress the significant difference between the “clinical course of otitis media characterised by early age of onset and high prevalence of severe disease” compared to that in non-Indigenous Australian populations. (OATSIH, 2010, iii and iv).

These descriptors and the frustrating history of unsuccessful intervention for otitis media in young Indigenous Australians attest to the high likelihood that a single strategy, for example, the use of saltwater chlorinated swimming pools, would not in itself be able to show reduction in the prevalence of otitis media and related conductive hearing loss. The list of recommended primary health care and public health care priorities (Morris et al., 2005) required to tackle rates of severe otitis media is so comprehensive as to suggest that a uni-dimensional approach will be insufficient. Given the demonstrable lack of effect of swimming pools in this study directly on ear health and hearing, the evidence for reduced rates of clinic attendance and antibiotic prescription in 2 remote WA communities with swimming pools supports the notion of possible wider, rather than single disease, health benefits from access to swimming pools (Silva et al., 2008).

1st Recommendation from Conclusion 1: We recommend that swimming pools in Indigenous communities continue to be promoted as a valuable community resource for their broader benefits to physical health as well as social well-being. Our results do not support the earlier finding that swimming pools directly improve ear health and hearing in Indigenous children. However, swimming pools have an undisputed and important role in

any community for recreation, physical activity and for the self protection of learning how to swim. Regular swimming may over time result in generalised health improvements in children and a reduction of chronic infectious conditions, including respiratory, ear, skin or eye infections.

Comment: The participants in this study were all school-age children and adolescents. Regular use of saltwater chlorinated swimming pools by younger pre-school children might result in reduction in the formation of antibiotic resistant biofilms in those children with otitis media with fewer years of otitis media chronicity and conductive hearing loss. This possibility was not investigated in this study.

2nd Recommendation from Conclusion 1: Encourage greater use of the SPs by much younger children (including pre-school children). As described above this may assist in preventing the establishment of early nasopharyngeal and middle ear pathologies that are so difficult to effectively treat in remote communities. (Younger children would necessarily require the presence of a parent or guardian thereby also stimulating more community use of the SPs).

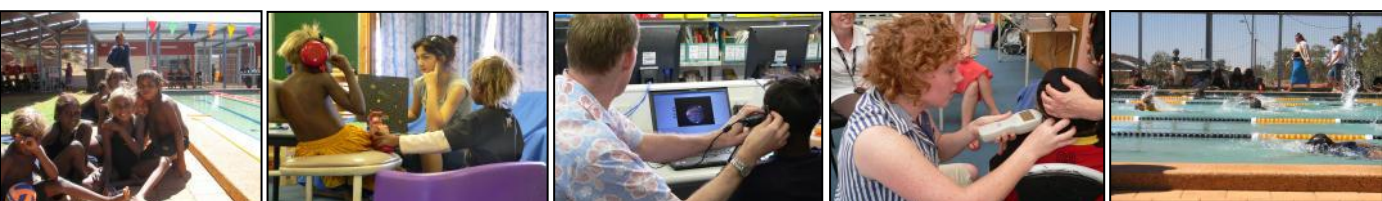
Comment: During the course of the research there were anecdotal comments from adults who live and work in the Anangu communities with pools that they observed improvements in the skin disorders of the school-age children. This was one of the reported areas of health improvement in the work by Lehmann et al. (2003). There is little in the literature to suggest that the effects of SPs on skin disorders have been substantially followed-up. Our SP study did not consider the effects of SPs on children's skin problems. Skin, ear and chest infections are very common in Indigenous communities. Skin infections are of major concern because they can lead to chronic heart or kidney disease later in life.

3rd Recommendation from Conclusion 1: There appears to be need for further research into the effects of swimming pools on the skin disorders of Indigenous children in remote communities.

Conclusion 2

There was no significant difference in school attendance (whether measured by attendance rate or absolute attendance in the number of days) between children in Pool and Non-pool communities.

Comment: The capacity of the 'No school No pool' policy to significantly improve school attendance rates in remote Indigenous communities with pools may be seen as simplistic or overly optimistic given the recognised complexity of the issue of school attendance in both non-Indigenous and Indigenous populations of students. Over-expectation of the benefits of a this strategy is unfortunate given the





complexity of the issue. As described in the report, cultural and socio-economic issues have particular bearing on lower school attendance rates in remote Indigenous communities. Further, it is recognised that the novelty of swimming pools lessens over time for students of all ages. Gender and cultural issues exert major effects on pool use by secondary students that makes the 'No school No pool' policy largely irrelevant.

Recommendation from Conclusion 2: We recommend the retention of the 'No school No pool' policy within the mix of strategies to optimise school attendance which are deemed to be appropriate for a locality and its school. The complicated issue of school attendance mandates a range of strategies to maintain and improve school attendance. Our results do not show a difference in school attendance between Pool and Non-Pool communities. Nevertheless the schools in the Pool communities now have smooth systems for managing the 'No school No pool policy' and it has support in those communities.

Conclusion 3

There are previously undescribed seasonal differences in the frequencies of eardrum perforations. The study has also demonstrated that mean hearing loss associated with dry perforations of the eardrum increases with age and that the size of dry perforations also increases with age. (These latter findings are not independent).

Comment: There is almost a two-fold greater risk of a school-age child having a wet perforation at the end of summer than at the end of winter. There is a smaller (about one-quarter less) chance of having a dry perforation at the end of summer. These variations probably reflect seasonal differences in environmental factors and social activities (unrelated to swimming pools). These data are important also as they expose a likely error in previously published work which concluded that swimming pool use reduces the prevalence of perforations of the eardrum.

Comment: There has been limited longitudinal research into the natural history of otitis media in Indigenous children. Morris (2005) reported the need to "identify the clinical features of otitis media with poor outcome" and to "provide a better understanding of otitis media in populations with high rates of perforation of the TM" (tympanic membrane). The combined data from the Flinders University service project in the Anangu schools, 2003-2008, and the SP study in the same communities will allow tracking of otitis media in a large sample of individuals who have a very high rate of eardrum perforation over a considerable time frame. This was beyond the scope of this SP study.

Recommendation from Conclusion 3: The clinical (audiological and medical) data provide an opportunity for longitudinal research into otitis media in Indigenous children, particularly children with perforation of the eardrum(s), which should be undertaken.

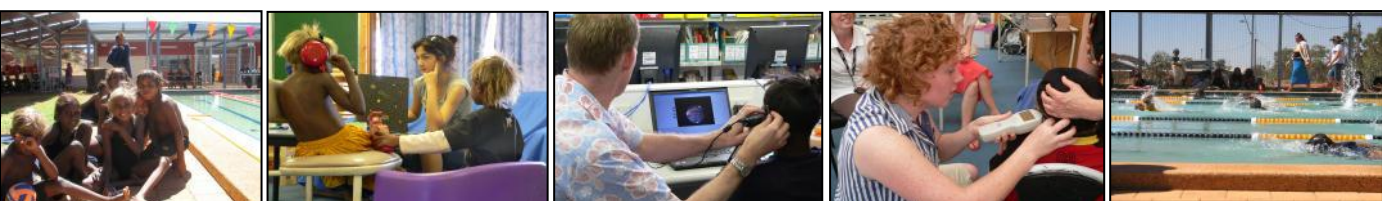
Conclusion 4

Our work over the past 9 years documents no improvement in either ear health or hearing in school-age Anangu children. Further, our data demonstrate that there are large numbers of secondary students who have serious middle ear disease which remains untreated. Many of these older students struggle educationally and socially with disabling poor hearing.

Recommendation from Conclusion 4: We recommend a strong cross-sectoral focus between Anangu education and health services on improving the hearing abilities of the Anangu children and adolescents with measurable hearing loss. We believe this is imperative given the well recognised and very serious consequences of hearing problems, overwhelmingly caused by otitis media, to the education and social and mental health of the many affected children. These ear health and hearing problems can be described as a scourge on individuals and the Anangu communities and maintenance of the status quo is unacceptable. Otitis media and the hearing loss it causes must be tackled vigorously and collaboratively by the communities and their health and education services. State and national programs provide models that Anangu may consider and adopt and adapt to address the problem.

Many Indigenous children in remote communities have disabling degrees of hearing loss due to eardrum perforation that are appropriate for surgical correction. In urban Australia a significant proportion of equivalently affected children would have had aggressive medical and/or surgical treatment. Successful ear surgery for the Anangu children would have significant social, educational and health benefits. While acknowledging and not seeking to minimise the practical difficulties of establishing surgical pathways, we reiterate the social justice nature of this issue that makes the development of surgical pathways in South Australia for remote Indigenous children an imperative.

Our data define the extent of the problem. We hope they can now be used as a robust benchmark against which to measure change.

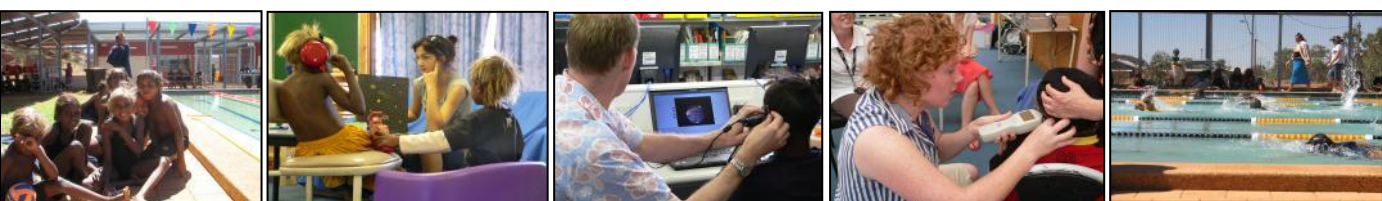




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List of Acronyms

Acronym	Definition
4-F PTA	4 frequency pure-tone average (an average of the hearing thresholds at 0.5, 1.0, 2.0 & 4.0kHz)
AC	Air conduction testing of hearing under headphones
AES	Anangu Education Service
APY	Anangu Pitjantjatjara Yankunytjatjara
CHL	Conductive hearing loss
CPC	Child Parent Centre (Pre-School)
CSOM	Chronic suppurative otitis media
DECS	Department of Education and Children's Services (of South Australia)
DECD	Department of Education and Child Development (of South Australia) New department name as of 2012.
DHA	Commonwealth Department of Health and Ageing
FU	Flinders University
HPE/DHA Report	Health Planning & Evaluation Pty. Ltd. Report
ME	Middle ear
NHC	Nganampa Health Council
OM	Otitis media
PYEC	Pitjantjatjara Yankunytjatjara Education Committee
PTA	Pure tone audiometry
SA	South Australia
SP	Swimming Pool(s)
TM	Tympanic membrane
WA	Western Australia



Aims and Objectives

Aim

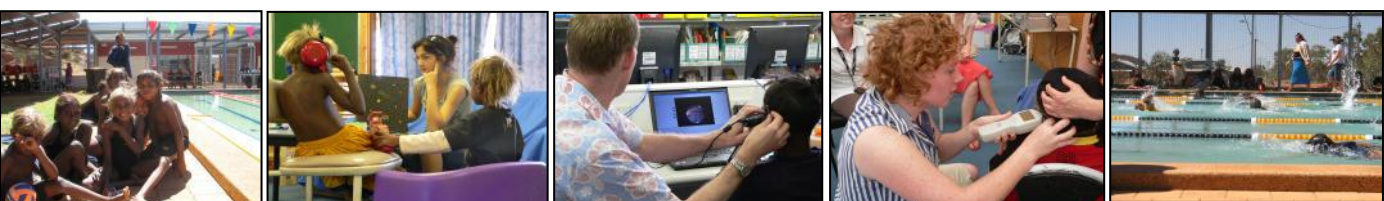
The original overall aim of the project was to investigate whether the use of swimming pools by pre-school and school-age Indigenous children in remote communities results in the reduction and possible prevention of conductive hearing loss related to middle ear disease (otitis media) in the children.

Objectives

1. To test, in a new and larger study, with high statistical power, the previous conclusion which found that the use of swimming pools by Indigenous children in remote communities significantly reduced the prevalence and nature of one indicator of ear health (perforation of the eardrum).
2. To significantly extend the previous research by incorporating measures of hearing (audiometry) and middle ear function (tympanometry) as the critical outcome measures which are more directly linked to educational outcomes in these children.
3. To significantly extend previous research into this question utilising both existing data and data to be acquired in this project to study the longitudinal effects of access to swimming pools on ear health and hearing. Communities without pools will be controls and prior data and data to be collected will provide a unique opportunity to study the longitudinal effects of pools in a short time frame.
4. To investigate the question whether the benefits of the swimming pools to ear health status and hearing are greater in younger indigenous children, 3-7 years of age, than in older children, 8 years and above.
5. To utilise all the longitudinal hearing data across all sites to investigate the natural history of otitis media with effusion (OME) and conductive hearing loss in indigenous children as a function of their age (including any seasonal variation).
6. To provide, as an outcome of the above objectives, critical information about the ear health and hearing status of individual pre-school indigenous children aged 3-5 years, in line with the latest Federal government policy priorities for this age group, in relation to improvements in their ability to acquire literacy and numeracy skills in

comparison to the very poor levels currently found in older indigenous children.

7. On an ongoing basis to provide information on individual children to assist in their triage for ear health intervention and, where appropriate, increased educational support. (This would need the agreement of the Aboriginal controlled health services on the APY Lands and the health service organisation for the Yalata and Maralinga Tjarutja Lands)





Background: Geography, Population Demographics, Communities, School and Health Administration

APY Lands: Anangu Pitjantjatjara & Yankunytjatjara Lands

The APY Lands are part of the Western Desert cultural region in the far north-west of South Australia. They cover an area of about 103,000 sq km (about one tenth of the land area of South Australia). The northern boundary is the border between South Australia and the Northern Territory. The western boundary is the border between South Australia and Western Australia (Fig 1.). The APY Lands are semi-arid with hot to very hot summers (the mean maximum daily temperature is $>30^{\circ}\text{C}$ for 5 months of the year) and cool winters. Due to influences from the north the summers are moderately wet and the winters relatively dry.

The Pitjantjatjara and Yankunytjatjara people, known as the Anangu, own and administer the Lands under the provisions of The APY Land Rights Act passed in 1981. The governing body is the Executive Board of 10 members elected by Anangu in accordance with the APY Land Rights Act. The board members are elected for a 3 year term under an election supervised by the SA Electoral Office. The Executive Board selects its own Chairperson.

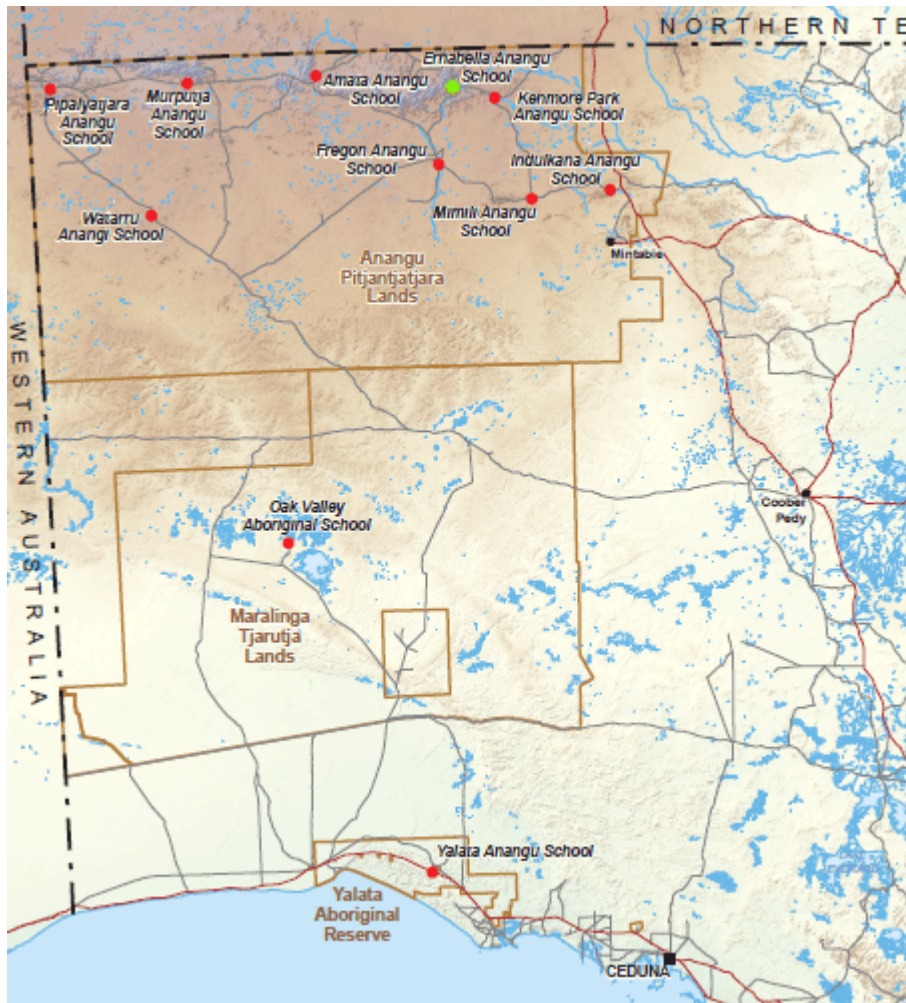
Anangu have unrestricted rights of access to the Lands while other people require a permit to enter the area with some exemptions such as for police, Members of Parliament, Electoral Commissioners and in cases of emergency.

Maralinga Tjarutja and Yalata Lands

The Maralinga Tjarutja Lands are located in the far western region of SA. The Anangu people were moved from this area in the 1950s to make way for nuclear tests undertaken by the British Government. Native Title was handed back to the Maralinga people in January 1985 under legislation passed by the South Australian Parliament in December 1984. The land was resettled in 1995 centred on the community of Oak Valley on the southern edge of the Great Victoria Desert about 500kms north west of Ceduna. The Maralinga Tjarutja Council is an incorporated body which administers the Lands on behalf of the Anangu.

Yalata community is located 200 km west of Ceduna near the coast of the Great Australian Bight. The people are Anangu, who were removed to Yalata in 1952. These southern Anangu speak Pitjantjatjara as their first language. Yalata holds the title to its land under a 99 year lease from the Aboriginal Lands Trust. It is administered at the local level by the Aboriginal Council of Yalata

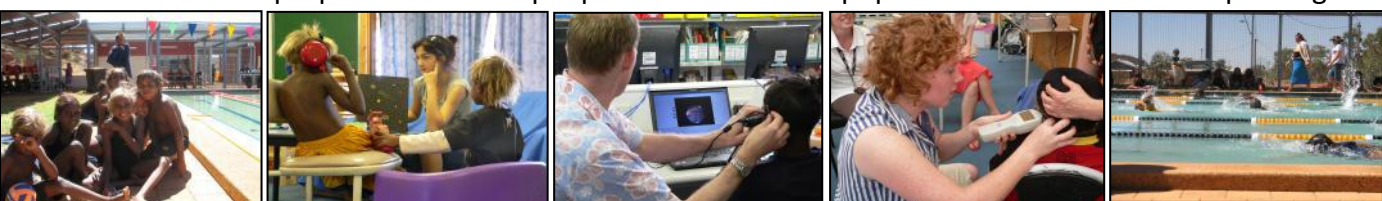
Figure 1



Population and Demographics

The population of the Anangu Lands (APY Lands and Maralinga Tjarutja and Yalata Lands) varies depending upon the season and activities such as cultural meetings and sporting events.

The 2006 Census conducted by the Australian Bureau of Statistics showed a population of 1845 individuals identifying as being Indigenous. There was a significantly higher proportion of younger people than the overall Australian population and correspondingly a significantly lower proportion of older people than the overall population. 58.6% indicated speaking



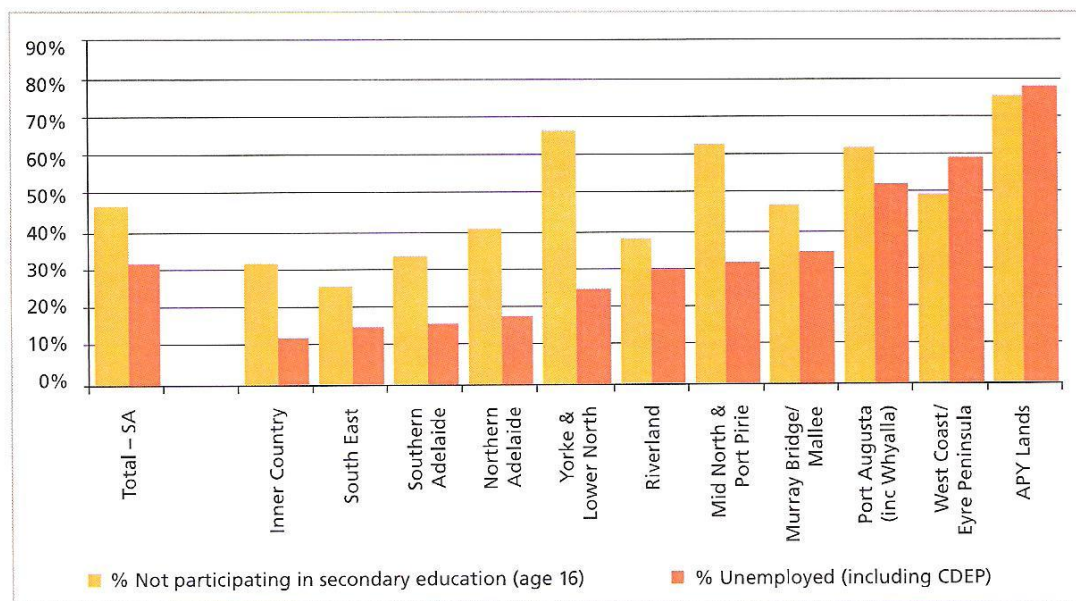


Pitjantjatjara at home, 14.3% Yankunytjatjara and 18.7% English. Anecdotally it is widely believed that the census under-reports the actual number of resident Indigenous people. An alternative (lower-bounded estimate) is included in Table 1. Other estimates of population can be found in the *Children on the APY Lands – Commission of Enquiry* (Mullighan Report (2008)) which contained two estimates of the population, one provided by Nganampa Health (pop. 2734) and one provided by Tjungunku Kuranyukutu Palyantjaku (pop. 2479).

Aboriginal unemployment across SA is also higher than in the non-Aboriginal population as is welfare dependency and the percentage of children growing up in jobless and/or low income families. Figure 2 demonstrates that both the highest level of unemployment among Aboriginal people and the highest level of non-participation in secondary education at 16 years occurs in the APY Lands.

Figure 2*

Aboriginal Social Disadvantage: Unemployment and Non-participation in Secondary Education



Source: ABS Census 2006 and CDEP Participants, Department of Families, Housing, Community Services and Indigenous Affairs, June Quarter 2007

*Source: SA Health: Aboriginal Health Care Plan 2010-2016: ISBN: 978-1-74243-208-3 (pbk.) available online

The APY Lands and Maralinga Tjarutja Lands and Yalata Communities

There are 11 communities on the APY Lands as listed in Table 1 plus associated homelands. Umuwa is the administrative centre of the Lands and the site was chosen because it is

culturally neutral. Oak Valley and Yalata are the communities on the Maralinga Tjarutja Lands and Yalata Lands.

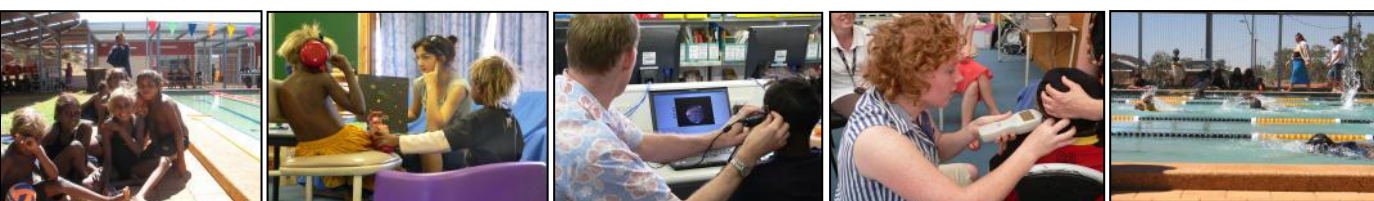
Municipal Service Officers (MSOs) are administrators employed by community councils and living in the communities. In each of the communities there is a community council which is elected by the members of the community. The MSOs undertake the day-to-day administration of the communities and are subject to the control of the councils.

TABLE 1
Population data for APY and Maralinga Tjarutja & Yalata Lands Communities: 2006 Census Population Data and estimates of population by the *Anangu Lands Paper Tracker**

Community	Indigenous Residents (2006 census)	Indigenous Residents (Anangu Lands Paper Tracker: 2012)*
Indulkana	315	>300
Mimili	283	>200
Fregon	212	>200
Ernabella	286	>400
Amata	289	>300
Murputja /Kanpi /Nyapari	86	>100
Pipalyatjara	96	>100
Kalka	107	>100
Watarru	unavailable	75
Kenmore Park	unavailable	unavailable
Yalata	82	200
Oak Valley	98	100
Total	1845	>2075

*http://www.papertracker.com.au/index.php?option=com_frontpage&Itemid=1

The communities on the Lands have small populations (see Table 1) and are mostly widely separated (Fig. 1). There are no sealed roads or public transport and the roads are often in poor condition as a result of poor weather and infrequent grading services. There are airfields for small aircraft at or near most major communities but not all the airfields are sealed and suitable for all weather use. Telephone and TV services are available and mail delivery by air is once or twice per week from Alice Springs. There is a permanent police presence and police stations in Mimili, Amata, Ernabella, and Yalata (there are police facilities also at Murputja). Community constables are also located in some communities and there are plans to fund more positions.





Each of the communities has community housing as well as a number of teacher, health and other staff houses. a health clinic and a store from which food and other essentials brought in by truck may be purchased. Mimili, Pipalyatjara, Amata and Yalata have a community swimming pool. Community run Arts Centres are located in Indulkana, Mimli, Fregon, Ernabella, Amata, Nyapari and Kalka.

Infrastructure and Administration of Anangu Schools

The main communities have a school (Reception to Year 12) and Child Parent Centre (CPC) for preschoolers. Children from Nyapari and Kanpi attend Murputja Education Centre and children from Kalka attend the school at Pipalyatjara.

The APY Lands schools work under the joint management of DECD and the Pitjantjatjara & Yankunytjatjara Education Committee (PYEC). The latter was granted policy control in 1987 and operational control in 1990. The PYEC consists of an Anangu coordinator and representatives from each community and makes decision about the directions of schooling.

In Yalata and Maralinga Tjarutja the management and the governance of education are the subject of ongoing negotiation.

Anangu Education Service (AES) is the service provision unit within the Aboriginal Lands District of DECD. It provides education services for communities situated within the APY Lands, the Maralinga Tjarutja Lands and the Yalata Lands.

Schools receive support from the AES which includes a support service team (guidance officer/psychologist, hearing impairment coordinator, speech pathologist) which visits regularly to assist students. There is a Disability and Wellbeing manager, literacy support and early childhood coordinator. The AES Office in Adelaide provides services in, for example, management of policy, public relations, liaison with other DECD services, recruitment, curriculum and resources development. The AES office located at Ernabella is managed by Anangu Education through the Coordinating Principal. This office also has training and development facilities and is used primarily as a base for Anangu teacher support.

Health Service Administration

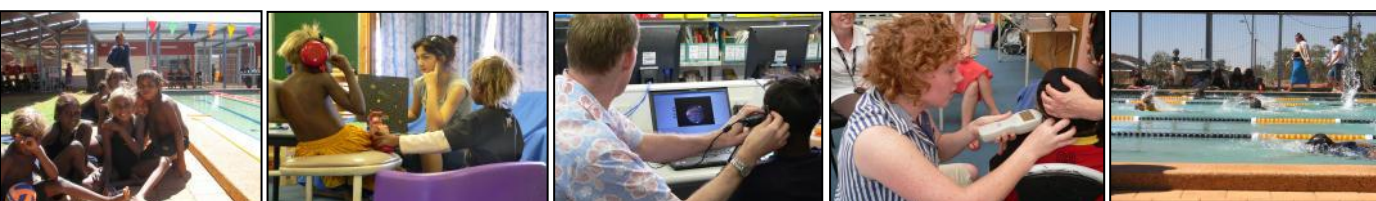
Nganampa Health Council

Nganampa Health Council (NHC) is an Aboriginal controlled organisation that provides health services and health related programs on the APY Lands. It is a non-government incorporated association governed by an Aṅangu board. The Director and all clinic managers are Aṅangu with a non-Aṅangu medical director.

There are six major clinics at Ernabella, Indulkana, Mimili, Fregon, Amata and Pipalyatjara and 3 clinics in smaller communities at Kenmore Park, Nyapari and Watarru. The NHC administration centre is in Umuwa. A 16 bed aged care facility is located at Ernabella. There is also an administrative office in Alice Springs.

Tullawon Health Service - Yalata

Yalata Maralinga Health Service Inc (YMHS) was established in 1982 following community initiative and lobbying by Yalata and Oak Valley residents. In the late 1990s Oak Valley developed its own Health Service OV/Maralinga Health Service. The YMHS constitution was amended in 2001 and the name changed to Tullawon Health Service. Tullawon Health Service is an incorporated association located at Yalata community. There is a Board of Management responsible for providing the strategic direction. The Board of Management is chosen at annual general meetings by the members (Aṅangu adults of Yalata and Maralinga Tjarutja Lands). The Chief Executive Officer and the Aṅangu Executive Director (AED) are jointly responsible for executive management under the strategic framework identified by the Board. The Medical Director advises and guides the health services and programs, including the work of visiting doctors and specialists. The Medical Director reports to the CEO and AED.





Background

Otitis media and conductive hearing loss in young Indigenous Australians

Hearing loss caused by middle ear disease, otitis media, is a very common finding in a high proportion of Australian children under 5 years of age. Otitis media (OM) is the commonest cause of conductive hearing loss (Gelfand, 1997). For the majority of young non-Indigenous children episodes of OM either resolve spontaneously or with appropriate medical treatment. However, OM¹ (see definition in footnote) tends to have a very different natural history and characteristics among young Indigenous Australians, especially those living in communities in remote areas of Australia. OM in Indigenous children: (i) occurs much earlier than in non-Indigenous children, usually within the first few months of life and (ii) affects ear health and, consequently, also the child's hearing for a much longer period of time than for non-Indigenous children. The cumulative duration is estimated to be an average of 2.5-3 years during childhood compared to 3 months in a non-Indigenous child (Couzos, 2001) and (iii) often progresses to a chronic form of the disease with eardrum perforation and discharge from the ear.

OM is considered a disease of poverty (Morris et al., 2005). In Indigenous children in remote communities its early onset is perpetuated and exacerbated by public health and education issues such as inadequate housing and domestic overcrowding, lack of running water and hygiene problems, inadequate nutrition, low levels of education and reduced access to medical care.

Conductive hearing loss is the usual consequence of OM where pathological changes to the eardrum and middle ear cavity prevent efficient transfer (conduction) of sound waves to the cochlea. Conductive hearing loss can range in degree from slight to moderately severe depending on the severity and type of OM experienced. Another characteristic of conductive hearing loss is its fluctuating nature. This adds an unsettling element of temporal inconstancy to the child's auditory experiences and may affect their perceptual development and listening confidence. The young Indigenous child typically has frequent episodes of OM with accompanying conductive hearing loss from a very early age which impact on their early development and later education. The child's development of speech

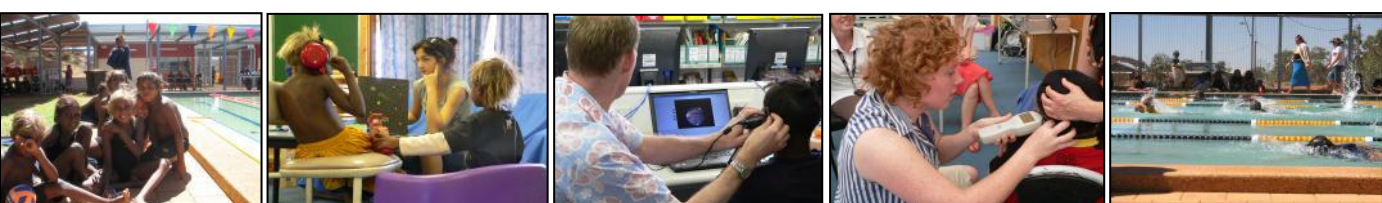
¹Otitis media refers to all forms of inflammation and infection of the middle ear. It includes otitis media with effusion (OME), when fluid is present in the middle ear behind an intact eardrum; acute otitis media (AOM), which is a sudden inflammatory infection causing ear pain; chronic suppurative otitis media (CSOM), when there is active disease in the middle ear over at least a 2 week period with a perforated ear drum. "Dry" perforations are almost exclusively due to prior chronic suppurative otitis media.

and language, in their first language as well as in English, may be delayed and/or disordered (Zubrick et al., 2004; Aithal et al., 2008). The persistence of hearing problems into the school years leads to under-achievement, even educational failure, possible behaviour problems and greater likelihood of poor school attendance and of leaving school early. In Australian data reported in 2004–05, young Indigenous people who had left school at Year 9 or earlier were around twice as likely as those who had completed Year 12 to have or have had ear/hearing problems and heart/circulatory diseases. (ABS, 2008)

A child with bilateral OM with effusion (fluid in the middle ear) is likely to have a hearing loss of approximately 25 decibels (dBHL). This is outside the range of normal hearing (commonly agreed to be: -10 to +20dBHL). Although audiologists describe this as a mild hearing loss, it is sufficient to impair aspects of conversation with another person. A mild hearing loss will have a still more pronounced effect on a child trying to hear and process speech in noise, such as in an overcrowded home or a classroom. The impact of a mild hearing loss on a child, particularly in a learning situation with new vocabulary and content, cannot be compared to the effects of a similar level of hearing loss on an adult who has developed linguistic skills and various decoding strategies. Chronic suppurative otitis media (CSOM) causes more significant hearing loss; this is usually a hearing loss of approximately 35 dBHL, though more severe CSOM can cause a hearing loss of up to 60 dBHL. (Morris, 2009).

The high prevalence of OM and conductive hearing loss in Australian Indigenous children was first documented in the research literature in the late 1960s. Prevalence data over successive decades have continued to document extraordinarily high levels of OM, particularly in children in remote communities. In a 2002 survey 709 children from 29 communities throughout the Northern Territory aged between 6 and 30 months (over 90% of this age group in the communities) were examined by the Menzies School of Health Research. An overall average of 25% of these very young Aboriginal children had perforated ear drums, 31% had middle ear fluid in both ears and only 7% of children had normal ears. Five communities had perforation rates greater than 40%. (Morris, 2005). These levels exceed those reported for other Indigenous populations worldwide.

Otitis media in Indigenous children has proved intractably difficult to treat and the prevalence rates for OM and conductive hearing loss in remote Indigenous children have shown no signs of significant improvement in the past decade. The intractable nature of OM of long standing may relate to the establishment of biofilms on the mucosal surface of the ME. Biofilm is a complex slime-like structure produced by bacterial colonisation. Bacteria may persist within a biofilm while being culture negative. Biofilm is protected from the immune system and is highly resistant to antibiotics. As such it is a reservoir for re-infection leading to recurrent OM without the need for exogenous infective agents. Biofilm has been





observed in 92% of ears with chronic OM (Post, 2001). Coates *et al.*, (2008) identified biofilms in the ears of Aboriginal children.

There is now evidence that the impact of OM on a child's early education and the persistence of conductive hearing loss into adulthood has consequences for vocational training, employment and mental health in adulthood. Recent research in the Northern Territory among young Indigenous adults in the social justice system has linked the prevalence and severity of conductive hearing loss in young Indigenous Australians to a range of negative outcomes for employment and training opportunities and their overrepresentation in prison populations. (Vanderpoll & Howard, 2011).

Coates (2002) has argued for a huge increase in resources at national and state levels to tackle this issue with a spectrum of approaches. Solutions to middle ear problems are thought to ultimately lie in wide scale economic and public health initiatives. More access to employment and reduced domestic overcrowding will in turn effect improvements in living standards and general health for remote Indigenous families. But interim strategies are also needed to directly try to reduce the prevalence of OM and the impact of hearing loss on Indigenous children. One such strategy that has been widely but uncritically embraced in the past decade is the use of saltwater chlorinated swimming pools to prevent and reduce OM in remote Indigenous children, among other reported benefits to health. It is plausible (but unproven) that irrigation of the nasopharynx and the ME mucosa by (isotonic) chlorinated saltwater in perforated ears may facilitate the disruption of biofilm and hence reduce the risk of reinfection.

Lehmann *et al.*, (2003) reported that the provision of swimming pools in two Indigenous communities in remote semi-arid Western Australia significantly reduced skin and ear disease in children and young people. Continuation of the study until 2005 (Telethon Institute for Child Health, 2006) showed maintained improvement in the perforation prevalence rate in the less mobile community (15%) but more variability in the data in the other community which had significant periods of pool closure and more mobility of its residents. Limitations of the WA study include: i) the lack of control communities without pools ii) a very low number of baseline assessments (pre pool) against which to measure change. iii) the relatively small numbers of children in both communities who were studied and iv) the issue of resident mobility impacting on continuity of follow-up.

The impact of this work was substantial and stimulated action in building swimming pools in remote communities. Further it was linked to efforts, such as in South Australia, to improve school attendance and retention rates among Indigenous students. "The construction of swimming pools near schools has the dual benefit of improving school retention through a "No school No pool" program, and improving health by reducing ear, eye and skin infections." (Premier Mike Rann, 15/1/08, The Australian).

The positive findings of the WA swimming pool study have generally been applied uncritically to the benefit of swimming pools in remote indigenous communities. Whatever their broader recreational benefits, the related claims that swimming pools will reduce middle ear disease in Indigenous children, which in turn will improve their hearing and lead to improved literacy outcomes, required further systematic and sustained investigation. A much stronger evidence base for the benefits of swimming pools on ear health was needed with children's hearing status as an outcome measure, not perforation rates alone. It was possible that broader and more rigorous examination of the effects of swimming pools on ear health and hearing would yield stronger evidence for their benefits.

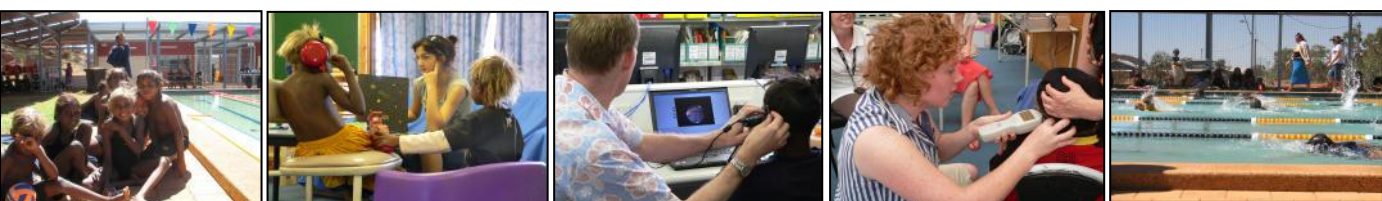
The construction of swimming pools on the APY Lands of northern and western South Australia between 2005 and 2007 and the substantial audiological work carried out by Flinders University with school age children in remote Anangu communities on the Lands between 2003-2008 provided an opportunity for the further research stimulated by the WA study.

Flinders University's Service Project Work in Ear Health and Hearing in the Anangu Schools, 2003-2008

At the invitation of the Anangu Education Service (AES) of the SA Department of Education and Children's Services (DECS) all school-age children in the 9 communities of the APY Lands in far north-western SA were assessed annually or biennially between 2003 to 2008 by audiology, speech pathology and medical students with supervising Flinders University audiology staff (two of the current investigators). The two-fold aim of this work was:

1. to provide "whole of population" data about the extent of hearing loss and ear health problems among Anangu school children with a view:
 - a. to using the prevalence data to lobby for relevant infrastructure in classrooms and increased staffing levels;
 - b. to raise awareness of hearing loss among teaching staff and indigenous families and
 - c. to improve links with local health services to reduce the prevalence of middle ear disease.

2. to obtain information about individual children in order to better identify those who met eligibility criteria for assistance under the DECS Students with Disabilities program. This would accelerate: the "verification" criterion of two abnormal audiograms within 18 months to trigger DECS Hearing Impairment Sector services. Selective referral, principally by teachers, of only the likely "worst" cases for audiological assessment was thought to be missing a large number of eligible children. In practice it had been difficult to obtain the repeated audiometric evidence required for remote Indigenous children.





The audiological assessments of the children for the service project comprised a hearing screening test with threshold hearing levels determined for any child who did not pass the screen; standard otoscopy to examine the ear canal and eardrum, and tympanometry, to measure the health status of the middle ear by assessing the mobility of the eardrum. This protocol was used from the outset in 2003 and remained unchanged through 2008.

The population data on the hearing and ear health of the Anangu children in these years showed appallingly high levels of hearing loss and ear pathology. At the time of the application to the DHA for funding for the SP study, 1120 children had been assessed (each assessment involved audiometry, otoscopy and tympanometry, where appropriate) and many children were assessed on multiple occasions. Seventy four per cent (74%) of children failed a screening test of hearing and thirty-two per cent (32%) of ears examined otoscopically were perforated (of these 53% showed active ear disease and 47% had dry perforations). These data were used effectively by the AES to improve school infrastructure, such as the installation of sound field systems in all classrooms, increase staffing levels (the latter in relation to the increased proportion of children who met DECS criterion for a *Student with a Disability: Hearing Impairment* on the basis of our sequential audiograms on individuals) and to provide relevant information for newly recruited teachers with a view to improving the outcomes for school-age Anangu children with conductive hearing loss.

The prevalence data on hearing impairment and middle ear (ME) disease provided a strong foundation and an incentive for our application to the DHA to investigate whether the introduction of swimming pools results in a significant change in ear health and hearing to school age Anangu children.

At the end of the FU/DECS service project there were 4 communities with large and properly maintained swimming pools (3 on the APY Lands and 1 at Yalata). We expected that whole-of-population (school children) data and our experience in the communities would provide a platform for a definitive assessment of the benefits of the swimming pools for children's ear health and hearing on the Anangu Lands.

The assessment protocol for the Swimming Pool (SP) study with its longitudinal use of three measures, i) audiometry to measure hearing thresholds, ii) tympanometry to measure middle ear status and iii) criterion-based otoscopic examination, including video-otoscopy and medical diagnosis, in a large sample of Indigenous children was likely to provide definitive evidence of whether swimming pool use generates significant ear health and hearing changes likely to impact positively on longer term hearing.

It was proposed that such data would fill important gaps in understanding any role that swimming pools may play in improving ear health and in hearing loss prevention. Further such an outcome might have a wider impact in terms of justifying major investments by

government in swimming pool infrastructure and their ongoing maintenance in Indigenous communities. It was recognised that the results of this project would be applicable only to Indigenous communities in desert and semi-arid communities.

Research Plan

The Flinders Swimming Pool study has been a retrospective intervention cohort study. Application for funding was made to the DHA (Hearing Loss Prevention Program) in February 2008 and the project was approved in October 2008. After approved revision, the study's aim was to investigate whether access to and the use of swimming pools by school-age Indigenous (Anangu) children in remote communities results in the reduction and possible prevention of conductive hearing loss consequential to middle ear disease in the children.

The study was longitudinal and took place over three years starting in 2009. In the previous 3 years, 4 of the Anangu communities (3 on the APY Lands in northwestern SA and 1 in the Yalata Lands of far western SA) acquired large saltwater chlorinated swimming pools funded by the Commonwealth. However many of the other communities, both large and small, did not have pools and at that stage had no prospect of having one. These provided the experimental (Pool) and the control (Non-Pool) communities for this study. The study has also been strengthened by antecedent (pre-pool) data for all communities from the FU service project work described above.

Study communities

There are 9 communities on the APY Lands all of which have schools under the direction of the AES and the governing board, the Pitjantjatjara Yankunytjatjara Education Committee (PYEC). There are two communities with DECS schools for Anangu children in the far west of the State also administered by the AES (Table 2). The communities have been described earlier (p.5 *et seq.*).





TABLE 2

Major communities: Pool	Major communities: Non-Pool	Minor communities Non-Pool
Mimili	Indulkana (Iwantja)	Kenmore Park
Amata	Ernabella (Pukatja)	Watarru
Pipalyatjara (& Kalka)	Fregon (Kaltjiti)	
	Murputja*	
Yalata (south-west SA)		Oak Valley (Maralinga Lands)

* Murputja school is located between two small and physically close communities, Nyapari and Kanpi. Its combined enrolment exceeds that of the minor communities listed and it was included for bi-annual visits.

Study population

The study had a whole-of-population focus and the target group was all school-age children in the 11 communities. The sample was estimated to be 500 school-age children and adolescents. As in our earlier service project work, we worked in the schools and aimed to test every child at school on the day(s) of our visit.

On the Lands the community pools are managed by the schools and accordingly all children attending schools in the Pool communities are linked into a school time program of pool attendance in addition to the ‘No school No pool’ policy affecting after-school pool use. The policy does not apply to weekend pool use. Some of the other schools in the Non-Pool communities also have swimming programs for their students, involving travel to the pools on a weekly or fortnightly basis, but for these children there was no *regular* pool use. Detail about the community pools and the schools’ use of them is provided below.

Change to target population

In our original research proposal to the DHA we planned to assess the ear health of all children in the communities in the 0-17 year age range; (see Aims 4 & 6). A change was approved by the DHA in early 2009 to focus only on school-age children, i.e. 5 years and older attending school. The reasons put to the DHA for this change included the following:

- Among children and youth, the regular pool users are those attending school, as described above. Use of the pools by pre-school age children and infants and toddlers will be informal and difficult to document reliably. In contrast to the protocols described below that we will use to quantify the pool use by school-age children, it would be very hard to document pool use by younger children accompanied by their parent(s) or another family member.
- The main outcome measure of the study in relation to pool use is hearing level. The measurement of hearing by pure tone audiometry in children 5 years and over is well standardised with high reliability. This is much less the case for children under 5 years and pure tone audiometry is rarely the test of choice or possible for children under 3 years of age. Therefore pure tone audiometry can be optimally used, with extra measures in place to enhance test reliability in non-clinical conditions, with school-aged children but not with younger children.
- Further, as the school attendance rate in the Anangu schools has improved somewhat in recent years and is now thought to be around 70% (a figure we will document) we expect to be fully occupied carrying out the required hearing and ear health test battery on all school-age children within the 2 week, bi-annual, data collection periods in the 9 APY Lands communities and the shorter bi-annual assessment times in Yalata.
- Children aged 3-4 years attend CPCs (Child Parent Centres) in the communities. These typically function in the mornings only and not every day of the week. Access to these children is much more limited and would impose constraints to the rest of the program of data collection. Children's attendance at CPCs is also more erratic than for school-age children.
- Finally, the 0-3 year old children are much less likely to be consistently available for assessment for the purposes of the project. They do not yet attend formalised programs and there is no day care. Mobility is still very high among Anangu and very young children commonly travel with their mothers and are often out of the community.

Accordingly Aims 4 and 6 of the study were not pursued.





Clinical methodology and related protocols

The clinical assessment protocol

- Pure tone audiometry – the standard international measure of hearing acuity
- Otoscopy: standard otoscopy and video-otoscopy (Otoscopic examination always preceded tympanometry, which was not done in all cases, eg. if an ear had a perforated eardrum)
- Tympanometry: the standard international measure of middle ear compliance/function

Audiological assessment

The hearing data were the main outcome measure of the study in relation to the use of swimming pools. Our protocol for the collection of hearing data and middle ear measurements was unchanged from that of the preceding service project and had been well trialed over the previous 6 years. The initial hearing test was a screening test of air-conduction (AC) hearing at 20dBHL at 4 test frequencies in each ear (0.5, 1, 2 and 4kHz inclusive). Children who did not pass this hearing screen at one or more frequencies in either ear proceeded immediately to air conduction (AC) threshold testing (thereby defining the level of hearing loss). No bone conduction audiometry was carried out. Standard otoscopy always preceded tympanometry, however there was no need for a fixed order for the assessments. From our earlier work we knew that data collection was facilitated by the flexibility that variable order allowed and there was very little downtime in waiting. All three clinical measures (variably requiring 10-30 minutes per child) were taken in prompt rotation.

Screening audiometry: ambient noise conditions

Audiometry was carried out on each school campus. Soundproof or sound treated booths were not used. The accuracy of screening audiometry and threshold determination will be influenced by high levels of ambient noise. Accordingly the schools assisted by identifying locations for audiometry in which ambient and episodic noise would be minimised. Sound pressure level measurements (dBA) were determined in these locations using a Brüel & Kjær Sound Level Meter (Model 2203). Ambient noise levels were in the range 22dBA to 36dBA. The most common source of elevated ambient noise was from computer servers. Episodic noise occasionally exceeded 45dBA (eg. school buzzers, passing vehicles) but testers were aware of such high noise spikes and would re-present test signals accordingly. The Auraldomes used (headphones) are rated so that a hearing threshold of 20dBHL can be

measured accurately even in the presence of ambient noise of 50dBA (Roeser & Glorig, 1975).

Tympanometry

Tympanometric assessment of ME function was an important measure of closed ear disease to assess the possible effect of SPs on measures of ME disease and hearing other than eardrum perforation alone. The current guidelines for diagnosis of OM “requires assessment of the appearance of the TM by otoscope (or video otoscope) plus compliance or mobility of the TM by pneumatic otoscopy or tympanometry.” (OATSIH, 2010, p. 6)

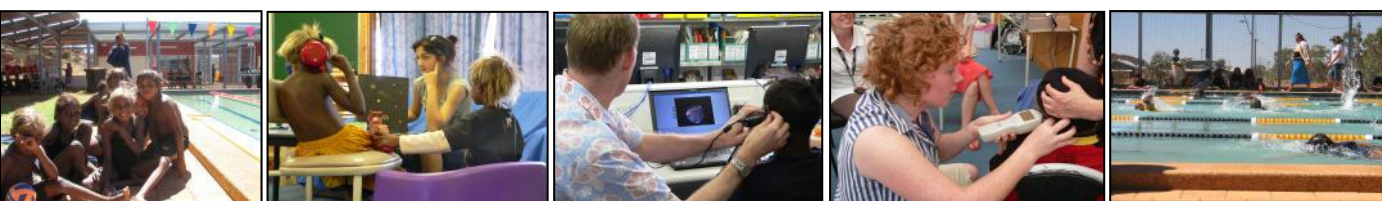
Prior to tympanometry every child was otoscopically examined either by standard otoscopy or VO. Children with an eardrum perforation(s) did not proceed to tympanometry. A child with a large amount of wax in the ear canal which seemed to occlude the canal and/or precluded visualisation of the eardrum, was still assessed tympanometrically. The result, in the measure of the ear canal volume, usually indicated whether the earwax was a complete barrier to the tone probe, thereby rendering the result an artefact, or not. Acoustic reflex testing was not carried out.

Tympanometry measures that were recorded included: ear canal volume, the TM compliance and the middle ear pressure. Tympanograms were classified according to the Jerger classifications (Gelfand, 1995). Other outcomes were: No Seal, if the ear canal could not be adequately sealed by a probe tip on repeated attempts, or Not Performed, if no test was performed. The latter was the case for perforated TMs and on the rare occasions when a child refused the procedure. The two tympanometers used provided print-outs and printed results were available for almost all children. This allowed later reconsideration and reinterpretation of some of the more clinically ambiguous results in conjunction with other assessments.

Clinical (otoscopy) examination and diagnosis:

All children underwent standard otoscopic examination followed by both tympanometry and video-otoscopy (VO). Video-otoscopy was used to collect an adequate video of the child’s otoscopic landmarks rather than a series of static VO images. At the same time as the VO data were being collected by the ENT specialist, he/she completed the diagnostic pro-forma designed for this purpose (Appendix 2). The videos were stored on the computer hard drive and routinely backed-up to DVDs.

There were only 3 of the total 12 weeks of data collection on the APY Lands when an ENT specialist or advanced ENT trainee was not part of the assessment team. The same advanced ENT trainee was present for all 6 visits to the Yalata community. For the periods





without a doctor, audiologists on the team gathered the VO data, which were subsequently assessed by an ENT specialist in Adelaide, who was employed on the grant for this purpose,

and who completed the same diagnostic pro-forma for each child based on the VO images. These post-hoc assessments were completed within 4-6 weeks of the visit for timely feedback to the local clinics and for entry of the full audiological and medical data into the database. A pro-forma for the clinical (medical) diagnoses based on otoscopy/video-otoscopy was developed based on the updated classification of chronic otitis media (Scott-Brown, 2008).

Well in advance of the first data collection visit discussions were held with the medical directors of the respective Aboriginal controlled medical services in each location, namely Nganampa Health Council, the health service on the APY Lands, and Tullawon Health in Yalata, about the clinical protocols, feedback of the medical information to the local clinics and mechanisms for local delivery of some of the recommended treatments.

Study schedule

The 8 major communities (4 Pool and 4 Non-Pool) were each to be visited twice annually, in March/April and in September (6 visits to each target community in total over the duration of the study). It was expected that the children from Oak Valley (N <25) would come to Yalata for testing once per year. Kenmore Park and Watarru schools would each receive annual visits. Each visit to the APY Lands was planned to be of 2 weeks duration enabling all 8 target communities to be visited. In this way all children in school on the day(s) of the visits would be assessed and a large proportion would be seen on several occasions during the course of the research. Results would be fed back to the AES, Australian Hearing (as appropriate) and to their respective Health Services.

The timing of the visits allowed us to test for any seasonal variation in ear health related to pool usage, given that pool usage would have been maximal over summer and there would have been no or minimal pool usage in the 5 months prior to the September visit.

Yalata was also to be visited twice per year by a smaller team in the same months over a period of 2 days.

Documenting swimming pool use

There were two levels of documentation possible with regard to swimming pool use.

1) **At the community level:** We obtained confirmation from the swimming pool managers and, at the end of the project, from the regional manager of all the pools, that the 4 swimming pools were operational and open for regular use during the swimming periods of the study, namely the summers of 2008/2009, 2009/2010, 2010/2011.

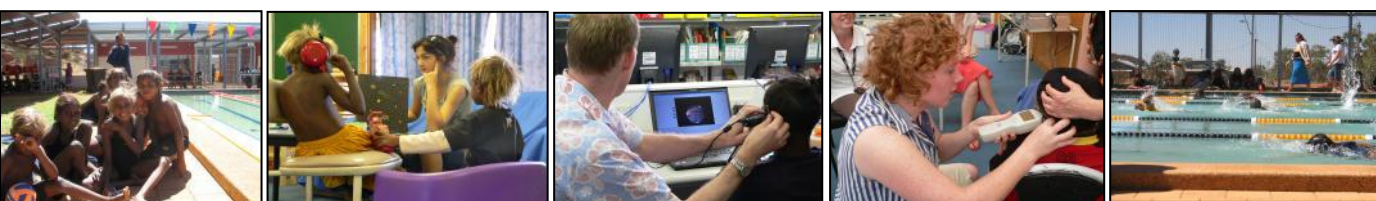
2) Use of the swimming pools by students at school in the communities with pools:

Contrary to our original information, pool managers did not keep records of the individual children who attended the swimming pool to swim after school. This had proved impossible administratively. Accordingly it was not possible to categorise individual children in terms of the frequency of their pool use. The surrogate or indirect measure for their pool use was via the school attendance records. According to the 'No School No Pool' policy children who did not attend school or who only attended for a fraction of the day, did not have access to the local pool later in the day. As all the primary school age children, and a variable number of secondary students, also have swimming lessons in the weekly curriculum of Terms 1 and 4, a child with low school attendance would also miss more of the within-school hours use of the pool. These school attendance data have accordingly been used to estimate pool attendance.

Equipment and calibration

All equipment used for the assessment of hearing and ear health was purchased specifically for the purpose of the project and is the property of Flinders University (see Appendix 3 for a list of the equipment). Calibration of the portable screening audiometers was done in house by the experienced staff of the Biomedical Engineering Dept. of Flinders Medical Centre/Flinders University prior to each visit (6 monthly). The tympanometers also received formal calibration checks in addition to frequent biological checks on specific individuals.

Standard equipment for each visit to the APY Lands comprised 6 audiometers (4 core and 2 spare), 3 tympanometers (2 core and 1 spare), 10 standard fibre optic otoscopes, 2 video-otoscopes and 2 laptop computers. Other available equipment comprised an otoacoustic emission (OAE) instrument, an electronic scanner for data backup and a sound level meter. All clinical equipment was transported in hard shell Pelican[®] cases, which were impervious to dust and reduced the effects of shock impact on the very long distances travelled on unsealed and corrugated roads.





Research team

The team responsible for the data collection on each of the 6 visits to the APY Lands comprised: 3 audiologists (two of the 3 audiologists were chief investigators of the project and were present on all trips), an ENT specialist or advanced ENT trainee, the project officer who was present on all visits, and 8 students. The students participated on an unpaid voluntary basis and were recruited from the Flinders University Master of Audiology course, the Flinders University Graduate Entry Medical course, the final year of the Flinders University Bachelor of Speech Pathology course and the Flinders University Master of Speech Pathology course. Staff, other than the Investigators and the project officer, and all students who participated in the research data collection were trained in the specific research protocols during two information sessions prior to each visit to the APY lands. These two sessions included an in-depth discussion on research involving Aboriginal and Torres Strait Islander peoples (informed by the NH&MRC guidelines, 2003) and a session which explained in detail the specific research protocols and provided hands-on practical experience in these. Staff who visited Yalata community were relatively unchanging and to the extent that they differed were given one-on-one training. Students were not involved in the visits to Yalata community.

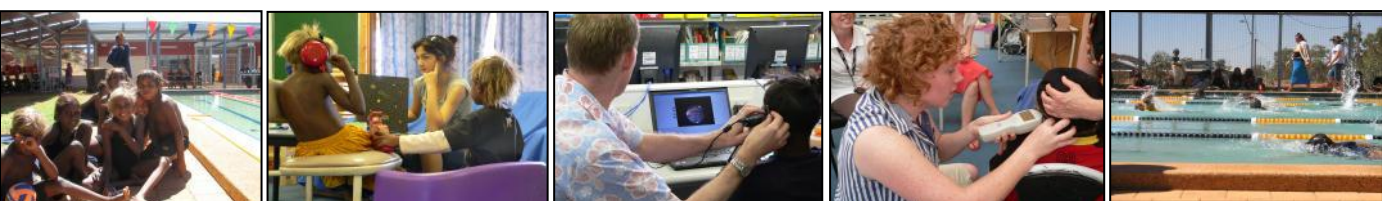
A Previous Swimming Pool Study

Immediately prior to this study, the Department of Health and Ageing through the Office for Aboriginal and Torres Strait Islander Health engaged an Adelaide based consultancy to carry out a 2 year evaluation of the sustainability and benefits of swimming pools for four communities on the APY Lands, 2007-2009. The final year of the earlier study overlapped with the first year of Flinders University's SP study. The report of the earlier study was released in mid 2010. (HPE/DHA Report, 2010).

One of the 5 objectives of the broad evaluation study was to "assess the health and social benefits of the swimming pools, including the extent to which the health improvements found in the Telethon Institute for Child Health Research study (Lehmann et al., 2003) have been replicated in the APY Lands communities" with pools. The survey's results in relation to health related benefits were "not as impressive as those seen in the Western Australian study." (HPE/DHA Report, 2010, p. 24). There was no evidence of any improvement in reduced ear disease across the 4 visits over 2 years, however there was a "decline in the number of children with pyoderma (skin sores) across all 4 study communities over the course of the evaluation." (HPE/DHA Report, 2010, p. 1).

The authors discuss a variety of methodological issues which they believe affected their findings. Some of these related to possible differences in the clinical competency of the staff carrying out the evaluations with variation in the composition of the medical teams over the 4 different visits; others related to the mobility of the Anangu families and the even higher rate of population mobility than had affected the WA study. This not only affected the repeatability of the clinical measures on the children, but is also likely to have meant that "pools may have been used only intermittently, which could potentially decrease the impact the pools might have as a health intervention." (HPE/DHA Report, 2010, p. 11). However there was no attempt to assess the proportion of time that children were in the community as a surrogate measure of pool utilisation.

Further comparisons between the present Flinders University study, that by Lehmann et al. (2003) and the study described in the HPE/DHA Report (2010) are presented in Appendix 4.





Operational issues related to the project

School attendance in remote Indigenous communities

The higher rate of school absenteeism among Indigenous students than among non-Indigenous students, and which is more pronounced in secondary school, continues to vex educators and politicians alike. Strategies to improve rates of school attendance by Indigenous students, particularly in remote communities, continue to be advanced and are the focus of regular articles in the national press. “Figures released in early 2011 in the Australian Productivity Commission's annual report on government services showed attendance rates for Year 10 indigenous public school students declined from 2007 to 2009 in every state and territory except Western Australia.” (The Australian, 24/2/2011). Controversy persists as to the relative importance of factors that contribute to poor school attendance. In a benchmark report (Bourke, Rigby and Burdon, 2000) the authors wrote that “various factors, issues and influences could be grouped under four broad headings – systemic factors, school/staff issues, student issues and parents/community factors.” Poor health was recognised as a factor for some children. Poor hearing was not specifically mentioned despite recognition that it can be a demotivating factor for students with respect to going to school and that hearing loss has a marginalising effect on the social aspects of being at school.

In the debate about school attendance it is acknowledged that different combinations of factors apply from school to school, region to region and even State to State. However, there appears to be significant commonality of factors in respect of poor school attendance among isolated, traditionally oriented, remote communities across the country. The report highlights “a growing body of opinion that 'in school' or school-based factors are of primary importance”, but recognizes that ‘out of school’ factors play a part in the high rates of absenteeism among Indigenous students, with some factors assuming particular significance. “There is, for instance, consensus in the literature that among the 'out of school' factors, mobility and frequent movement between schools play a significant role in Indigenous absenteeism, particularly in more remote, traditionally oriented communities, where long periods of absence between attendance at one school and the next, are a common occurrence” (Bourke et al., 2000, p. 51).

Attendance is seen as a complex issue requiring, among other things, modification of strategies to suit the local environment. Among the strategies to improve school attendance mention was made of strategies to assist hearing impaired students, such as culturally responsive pedagogy, classroom noise reduction, classroom amplification and increased use

of signing and body language. There is no mention of the need for efforts to reduce the prevalence of hearing loss affecting the majority of Indigenous children in remote communities. At the time of the report by Bourke et al., (2000) there was no mention of swimming pools as a strategy for community involvement in improving school attendance.

The potential for the use of swimming pools to improve health, including ear health, came to the fore after the widespread publicity of the results of a WA swimming pool study in 2003 (Lehmann et al., 2003). At the same time Shared Responsibility Agreements, which are agreements between governments and Indigenous communities to provide discretionary funding in return for community obligations, were being developed by the Federal Government. Funding for the capital development of swimming pools for remote communities became linked to their potential to improve health, to enhance school attendance (with the widespread uptake of the “No School, No Pool” policy) and to increase community development, training and employment in remote Indigenous communities.

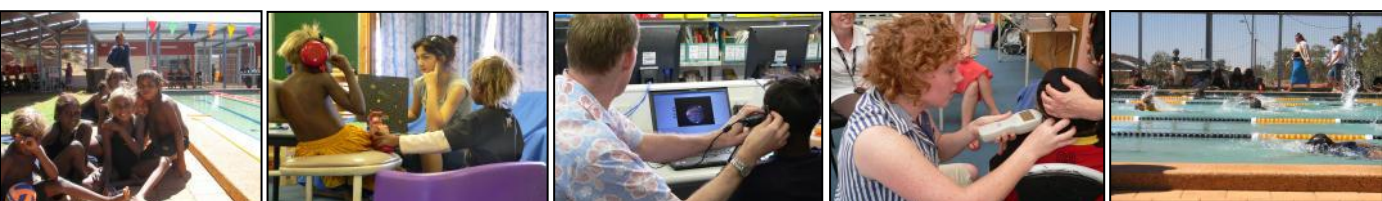
School Attendance in Anangu schools

Concern about school attendance of Anangu children has a well documented history (The Anangu Lands Paper Tracker, 2011) and has recently been under the spotlight again. “More than a third of students are not regularly attending school in South Australia’s remote Aboriginal lands, despite claims by the State Labor government of substantial improvements in the troubled region” (The Australian, March 13, 2012).

It is reported that in 2007, following a period of significantly improved school attendance on the APY lands between 2000-2007, the average attendance rate for Anangu primary schools was 73.7% compared to the State average of 92.8%, and the attendance rate for Anangu secondary students was 69.6% compared to the State average of 88.4%. The maintenance of the ‘No school No pool’ policy in Amata, Mimili and Pipalyatjara was one of seven programs or strategies pursued on the Lands in subsequent years to maintain and improve school attendance. The attendance rate for APY schools was reported to be 65% in 2011, the range being 58.5% to 77.3%.

Swimming Pool infrastructure on the APY Lands and in Yalata and related Government and community policies

In 2004 the Federal and South Australian State Governments originally funded the construction and operation of five 25-metre swimming pools in 4 communities on the APY Lands and in one community in the far west of SA (The Anangu Lands Paper Tracker, Oct, 2008; updated Nov. 2010). The first pool on the Lands opened in October 2006 and two others were completed by late 2007. Plans for one pool on the Lands in the smallest of the communities did not proceed.





The social, health and educational benefits that the State and Federal Governments expected the swimming pools, and their use by schools, to deliver included:

- sustained improvements in school attendance: In 2004 through a Shared Responsibility Agreement (SRA) between the Federal Government and the APY Lands Council, the communities where pools were to be constructed agreed to implement a ‘No school No pool’ policy with a view to improving school attendance as part of their commitment to better educational outcomes for their children.

An SRA with Community D in February 2007 included the stipulation that swimming would be included in the school curriculum as a fitness activity by Term 1 of 2008 (The Anangu Lands Paper Tracker, 29/9/2008).

- reductions in the incidence of ear, skin and eye diseases and infections.
- recreational activities for communities with substance abuse and family violence problems.

The pools first came under the management of the AES schools in the pool communities in October 2006 for Community F and subsequently when the pools at the other sites were officially opened. All Community Swimming Pool facilities are supported by a full time Regional Community Swimming Pool Manager based at Community F in addition to local pool managers. Local Pool managers at Community C and Community D are full time; Community F has two part time staff each working 15 hours per week.

The designated swimming season is from the first week of October to the end of the last week of the Term 1 school holidays the following year (before the end of April). Opening times are determined by the local Community Swimming Pool Committees. The facilities aim to be open 7 days per week in the peak summer period (i.e. all summer school holidays, except for the Christmas to New Year week) and are also open for community use on weekends and for some hours every weekday.

All of the pools were built as and initially operated as saltwater chlorinated pools, however since 2009 the Community B pool is no longer a saltwater pool. Although the Community B pool is not formally a saltwater chlorinated pool, the pool’s water is chlorinated but has a groundwater source with an osmolality approaching that of saltwater although with a lower sodium ion content. For the purposes of this study it functions as a saltwater chlorinated pool.

Three pools have the same dimensions, 25 meters by 12 meters. The fourth pool is a smaller pool comprising a 13 by 12 meter rectangle with a ‘free form’ shallow extension at one end

for use by very young children. This shape was the design preference of that community at the time when planning and community consultation occurred.

In 2010 Federal funding was provided for the installation of a solar water heater in the Community C pool to make swimming more comfortable in the early months of the swimming season and in March and April. It was not intended that this change would extend the swimming season. In 2011 there were similar plans for a new solar heater for the Community D pool.

All pools are operated in a mainstream manner as would apply in any city or country town. There are several levels of supervision and testing:

- i) The pools are overseen by the S.A Health Dept. with Health Inspectors visiting the pools regularly during the swimming season. Health Inspectors test water quality, examine mandatory log books and inspect the pool grounds. Records of visits are maintained.
- ii) The pools are formally the property of DECD and a DECD Inspector also visits all pools on average 6 times per year. This Inspector also checks the water quality and general infrastructure.
- iii) The water quality of all pools is additionally tested four times per year by an independent laboratory for the presence of E-coli and four other standard tests.
- iv) All Pool Managers are trained and hold current qualifications in Pool Management. Managers test water quality at least four times per day throughout the swimming season. During the swimming season each pool manager is required to report to the School Principal weekly.
- v) The Regional Manager of the Pools has confirmed that during the period of the research (2009 – 2011) no adverse conditions were found in any of the 4 pools pertaining to contaminated water, infected persons or incidents related to water quality or pool safety.

Use of the swimming pools by the schools

In 2011 the chief investigator interviewed the 4 principals of the schools in communities with pools about general aspects of the use of the swimming pools by their students, swimming lessons as a component of the school curriculum and the implementation of the 'No School, No Pool' policy.





Community B Anangu School. Interview with the principal, on 24/10/2011. The principal reported that regular swimming classes with the purpose of swimming instruction have not been possible at Community B School since the pool was opened. The inaugural pool manager had made a strong start with the development of procedures and protocols for the school's use of the pool and had started AUSTSWIM classes. However subsequent pool managers have not had the requisite skill range and/or have lacked a second qualified person to serve as a pool assistant, which is required by OH&S regulations. The teaching staff has not included a person qualified to teach swimming. Accordingly the principal reported that use of the pool during school hours has been "erratic". On occasion, during the swimming season, a class teacher will take his/her class to the pool "as a reward".

With respect to the implementation of the 'No School No Pool' policy, the principal commented that it has also taken time for a robust system to be put in place which identifies eligible student swimmers to the pool manager for pool access after school. Changes of pool managers or pool assistants meant that some did not know the children in the community well and on occasion admitted children to the pool who were not on the eligible list which was sent to the manager after school. In the spring/summer swimming season in 2011 a new system of coloured wrist bands (like hospital ID bands) was put in place, with a different colour band for each weekday. Before the end of the school day, the class teacher contacts the office to request a wristband for each child in the class who has been at school all day. The cut-off time for "all day" attendance at the beginning of the day is 9:30 AM when classes begin after a sport session.

The principal commented that there was less use of the pool by community adults than had been hoped for. The proximity of the coast (land under the community's ownership) means that families will often go to the beach on hot days to swim and fish. It is also cooler there than in the community.

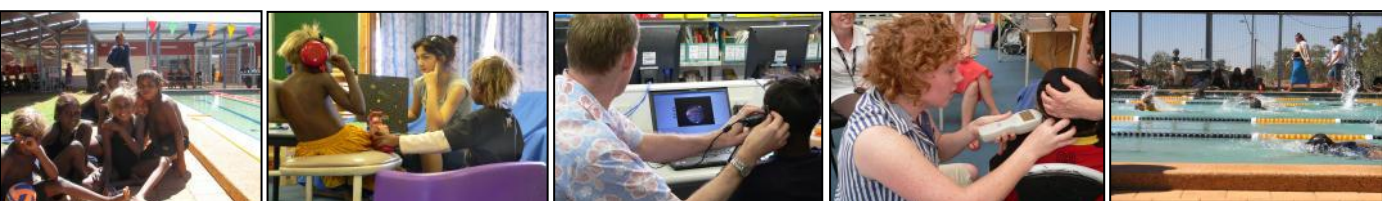
Community C Anangu School. Interview with the principal, on 21/3/2011: At C school swimming was part of the school curriculum for all years within the Health and Physical Education stream. All students at all year levels were expected to go to the pool for one lesson per week. The principal commented that this was linked to school attendance, however she felt that some children were becoming blasé about the pool and that its effectiveness as a measure to encourage better school attendance might be waning. However, in general she viewed their 'No School No Pool' policy as still effective with the primary age students. The principal also referred to it as 'No School (or Act the Fool)/No Pool policy' with reference to its occasional use within the context of classroom and school discipline. Students at C school get an arm band at the end of the day that signals their school attendance to the pool staff for entry to the pool after school.

There had been no disruption to the opening of the pool during the 2010/2011 summer period (except the usual Christmas –New Year closure) and the principal mentioned that extra effort had been made to double the staff available to ensure daily opening hours, from 11AM – 1PM. Community C had a full time pool manager and a pool assistant whose time was split between the pool (30 hours) and the school (5 hours). A designated teacher (consistently in this role) and an Aboriginal Education Worker had the primary responsibility for the swimming lessons.

Community D Anangu School. Interview with Principal, on 23/3/2011: At the time there were both a pool manager and a non-Anangu pool assistant who, in conjunction with at least one teacher and one Anangu Education Worker (AEW) for every lesson, provided 4 lessons per week to every class. The principal reported less uptake in some classes; in particular a lot of secondary female students were not going to the swimming lessons as well as some secondary boys. The staff also believed that many of these older students had more pressing curriculum needs and accordingly the formal (within school hours) swimming lessons for the secondary students had been reduced to 1 lesson per week. The principal commented that many of the older students swim recreationally after school and at weekends. When swimming resumed later in the year, the junior primary and primary students had 3 lessons per week and the pre-school children (under 5 year olds attending the pre school) had 4 lessons per week. The secondary classes have one lesson and the opportunity to join in both squad swimming and life guard sessions in addition to after school swimming. The principal reported that “most (younger) children swim every day after school.”

With regard to the ‘No school No pool’ policy, the principal commented, “We struggle to find a good system for clear communication that cannot be misused.” A system of stamping the children’s hands to show they had attended school and could gain pool entry after school had been replaced by the class attendance rolls being taken across to the pool immediately after school closed for the day. Children coming to the pool were ticked off against the roll by pool staff. They commented that this system was now generally working. The principal felt that attendance at Community D school was on a par with attendance at the other Anangu schools with pools. ‘No school No pool’ does not seem to have a lot of effect on older students but was felt to be a factor with younger students especially in Term 4 and on hot days. By the end of the swimming season, ie. Term 1, the incentive has waned.

The principal raised the issue of a dramatic occurrence in the summer of 2010/2011 when there was a “very noticeable” alteration in the composition of D community and nearby E community, a homeland community, over the summer holiday period. A large proportion of the families usually resident there had left the area for the holidays and other families had moved in. She speculated that this might result in many of the local children not swimming as regularly during the summer when they are away from the community for an extended period.





Community F Anangu School. Interview with the principal, on 29/3/2011: The principal flagged that in 2011 all students would have one 90-minute swimming lesson per week. However no lesson was scheduled for the senior secondary males (often initiated men) and the senior secondary girls. The principal felt that in general the senior students paid no attention to the ‘No School No Pool’ policy, but might go to the pool on hot weekends. She felt that in general pool attendance had dropped off. There were plans in place to stagger the opening hours of the youth shed (a source of extracurricular activities – especially music) and pool (in season) to encourage attendance at each and a range of activities across the age spectrum were being put in place.

A class list is delivered to the Pool manager after school by the class teacher with a list of student’s names that attended school all day. Only these students are allowed into the pool after school for 90 minutes. The principal asserted that “inappropriate behaviour at school cannot lead to a student not being allowed in the pool”.

Staff at Community F’s pool had developed a before and after school swim squad for interested students, with conspicuous early success for the team and for some talented and committed individual students. Further, some community students have achieved swimming proficiency enabling them to work as life guards at the pool after school and this has led to an increase in the pool’s opening hours.

General comment re the use of the pools on the Lands: The 3 APY Lands swimming pools offer ‘learn to swim’ opportunities for all students on the Lands, including those in Non-Pool communities. For example, many of the 20 or so students at one small school serving two homelands travel approximately 100 kilometres (each way) weekly during Term 1 and Term 4 in the school bus in order to have a swimming lesson and recreational swimming at the pool in Community D. There are also inter-school swim meets, including with some schools elsewhere in northern SA. Overall, however, the potential for daily access to pools is only available for children in pool communities.

Effect of Weather

Effect of weather on swimming activity

Anecdotally there were many comments from students in the 3 APY Lands communities with pools and in Yalata that they did not go to the pool or did not like swimming because the water was cold in the unheated pools (Mimili pool was heated from 2011 and funding became available that year for heating of the other two pools on the Lands). This was informally corroborated by teachers. The summer of 2010/2011 was cooler than usual in most of southern SA and the principal in Yalata reported that the swimming pool was open less and also less well attended during this period because of the cooler and wetter season.

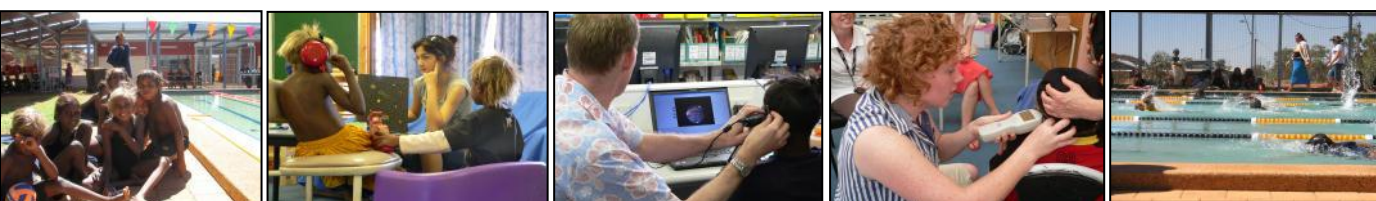
Effect of the weather on the conduct of the research

The schedule of visits and numbers of children seen are shown in Table 4. With respect to weather effects on the collection of the research data, there was only one occasion (Sept. 2010) when roads, impassable due to extremely wet weather, forced cancellation of the visit to the far west of the APY Lands (Pipalyatjara and Watarru). As a community with a pool, the research protocol mandated a visit to Pipalyatjara school twice a year, however as a very small community without a pool, Watarru was scheduled to be visited only once per year. Watarru was fitted into the schedule the following March (2011).

On a number of occasions, but notably over the full two weeks of our visit in September 2010, the poor condition of roads or outright impassability in certain stretches meant that alternative routes between communities had to be taken, resulting in greater distances travelled. Despite this the number of children assessed in September 2010 was still 85% of the average number assessed across the other visits.

Social factors influencing school attendance and/or the maintenance of the visit schedule

As described in the biannual research project progress reports to the DHA, most schedules experienced some disruption from events impacting on a specific community or communities at the time and usually reducing community numbers. Most commonly this was related to the nature of traditional customs and ceremonies of Anangu, such as funerals and related “sorry business” and sorry camps, with the location of the camps outside the communities. Family obligations require entire families to move out of the community and/or travel long distances to participate. There were also occasions of internecine disputes between communities and minor civil unrest which caused disruption to our data collection schedule. Families also travel to other communities for religious ceremonies (inma), football games, concerts and some inter-school competitions such as the annual dance competition. Although schools are careful with the scheduling of those major events which are within their control, some families do not return to their community in the immediate aftermath. “Business” related to the traditional initiation processes of young males, which often extends over many weeks, and simultaneously involves young males and their families from a number of communities, also meant that some of the secondary male students were absent from school for extended periods which on occasion included the times of our visits.





Concurrent clinical responsibilities

The clinical assessment of individual student's hearing and ear health, by both audiologists and medical specialists, for the purposes of the research, also generated separate reporting responsibilities to other key stakeholders for whom this information was important. These included: the principals of the community schools (and through them, the teaching staff); the Local Medical Officers of the community clinics and the visiting audiologists of Australian Hearing (AH).

Following each visit, photocopies were made of the hearing and ear health data for children assessed at that visit and sent by post to the schools and separately to the clinics. This provided a complete overview of the assessed population for the respective schools and clinics twice per year. The children with significantly poor results for either hearing and/or ear health were flagged for particular attention and follow up by the teaching staff and/or health clinic staff. A sub-set of children with poor hearing were referred to the AH audiologists who visit the Lands three times each year or to the AH audiologist who visits Yalata and Oak Valley. These referrals were made on the basis of audiometric criteria previously agreed with our AH colleagues for either bilateral or unilateral hearing loss. Most were children who needed additional, more comprehensive audiological assessment and/or whose poor hearing results suggested the need to fit a hearing aid, following discussion by AH with their family. A small number of the referrals were of young children who we could not reliably test in the time available for the research data collection and whose medical and audiological results caused concern.

Project Set- up and Consultation

Notification of DHA funding for the project was received in October 2008 for commencement of the project in early 2009.

To the extent that the research project was based on an existing program that had been underway since 2003 it already had the approval of the Pitjantjatjara Yankunytjatjara Education Committee (PYEC) which directs the Anangu Education Service. However, the expanded nature of the project in the Anangu schools with two data collection visits to the schools each year for a 3 year period and the need to share the medical diagnoses for each participating child with the respective health service in each location, among other things, required the PYEC to consider the proposed research work as a research project.

The PYEC's approval of the research project was obtained at their meeting of 12 November 2008.

Review Committee

In compliance with the DHA's request, a Review Committee for the project was established. The group comprised 4 members of academic staff from Flinders University, a senior administrator from DECS (external to the AES) and a liaison representative for the AES (ex officio). The academic staff members of the Review Committee were experienced in conducting research with Aboriginal people and in remote Aboriginal communities; their research spans areas of the social sciences, health, education, linguistics and Aboriginal studies.

The members of the Review Committee were:

Professor Andrew Butcher

Prof. Butcher is Foundation Professor of Speech Pathology at Flinders University. He is internationally recognised in the field of linguistics, with particular expertise in Australian languages. His current research includes ARC grants investigating aspects of Australian speech (in Aboriginal languages) in relation to hearing impairment.

Mr. Quenten Iskov

Mr. Iskov is Project Officer: Disabilities in the Dept. of Children's Education and Child Development (SA), with particular expertise in hearing loss in children. He has worked as a Hearing Impairment Coordinator (HIC/Teacher of the Deaf) and was the HIC for the Anangu schools on the APY lands for some years.

Dr. Inge Kowanko

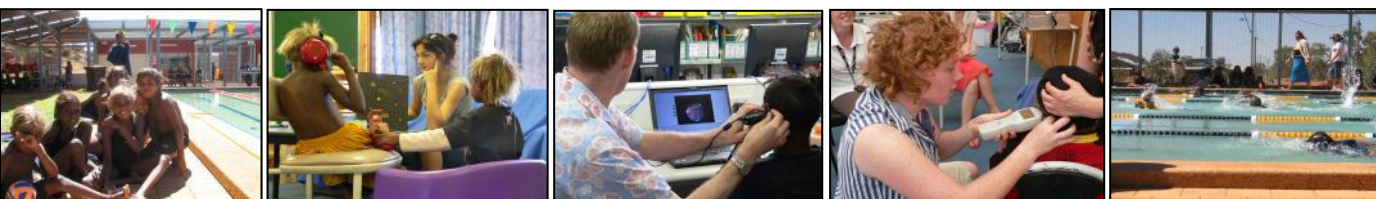
Dr. Inge Kowanko is a Senior Research Fellow in the School of Medicine and Leader, Flinders Aboriginal Health Research Unit. She was Flinders University's Link person with the CRC Aboriginal Health from 2003-2009. Dr. Kowanko has research expertise and current grants in a wide range of projects related to Aboriginal health, especially in the area of chronic diseases.

Professor Dennis McDermott

Prof. McDermott is Foundation Director of the Poche Centre for Indigenous Health and Well Being, Adelaide, at Flinders University. He is a Koori man who is a psychologist with over thirty years of experience in community health and Indigenous mental health.

Assoc. Professor Eileen Willis

Assoc. Prof. Willis is Head of Social Health Sciences, Faculty of Health Sciences, Flinders University. She has worked in remote communities in Western Australia and South Australia. A/Prof. Willis has broad research interests in the impact of social policies on the





health of populations and health care systems, with particular reference to Indigenous populations.

The Review Committee met on 6 occasions, on four occasions at biannual meetings and on two occasions by correspondence. At the face to face meetings the three Chief Investigators and the Project Officer were also present.

Ethics Approvals and Consent Forms

The Aboriginal Health Council of South Australia (AHCSA) represents Aboriginal health and the Aboriginal health advisory committees in South Australia at state and national level.

The Aboriginal Health Research Ethics Committee (AHREC) is a subcommittee of the AHCSA and is recognised by the NHMRC as a Research Ethics Committee. Proposals to conduct health-related research involving Indigenous people or communities in SA must be submitted to the AHREC in addition to the researcher's own institutional Ethics Committee.

The current project was submitted to the AHREC for ethics consideration on 02/02/2009 and approval was granted on 23/02/2009.

Flinders Clinical Research Ethics Committee (FCREC) is a joint committee of Flinders Medical Centre (now Southern Area Health Service) and Flinders University. The committee is constituted under the requirements of the NHMRC and Medical Research Council. A research application was submitted on 02/02/2009 and final ethics approval was received on 13/03/2009.

The research application included a parental consent form incorporated as part of the AES Schools' Swimming & Aquatic Consent Form. On the advice of the FCREC the original consent form was modified to include a section *Consent to take part in Flinders University APY Swimming Pool Study*. This included a short statement about the study and required a separate parental signature to provide agreement to a child's participation in the research.

Statistical validation and analysis

Prof. Adrian Estermann (University of South Australia) has been the statistical consultant to the project. The study has been a retrospective intervention cohort study. Prof. Estermann provided power calculations which were based on (i) our robust measures of hearing screening failure and documentation of ear pathologies in Anangu school children obtained between 2003-2007, and (ii) modest intervention outcomes.

Power

All calculations were based on 2-tailed tests with 80% power and a 0.05 level of significance. Table 3 shows the number of subjects required in each of the two study arms when changes in prevalence between baseline and end of study are compared between intervention and control communities.

TABLE 3

Outcome Measure	Control (Non-Pool) communities		Intervention (Pool) communities		N per group
	Baseline ¹	End ²	Baseline ¹	End	
% who do not pass hearing screen at any frequency in one or both ears	70%	70%	70%	60% ³	38
% with positive pathology based on otoscopy in one or both ears	37%	37%	37%	25% ⁴	32
% with positive pathology based on tympanometry in one or both ears	38%	38%	38%	25% ⁴	29

¹ Robust estimates based on data collected 2003-2007

² There was no reason to expect any major changes unless the project had led to a significant increase in medical intervention during the course of the study, which would then have applied to all communities. This did not eventuate.

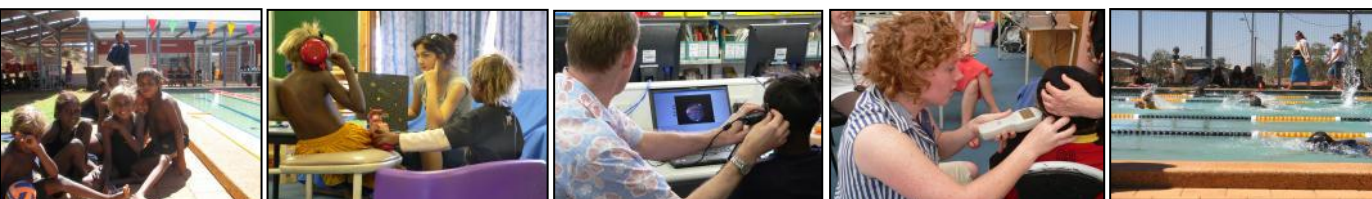
³ In the event of any changes it was expected there would be more robust changes in ear pathology than in the hearing screening pass rate which was thus reflected in the larger sample size required in the above Table.

⁴ Anticipated otoscopic changes were based on effects reported in the smaller WA study (Lehmann et al (2003)). Tympanometric estimates were chosen in line with otoscopic estimates (no equivalent data exist).

It was anticipated that there would be clustering by community, i.e., children in any given community being more alike than children in different communities. The sample size was therefore inflated by the design effect, where:

Design effect = $1 + (n-1) \rho$ where n is the average cluster size, and ρ the expected intraclass correlation coefficient (ICC) for the above outcome measures. There were no published data allowing us to estimate the ICC for hearing problems. However one paper had provided the ICC for diabetes in remote indigenous populations as 0.025 (Littenberg, & Maclean, 2006).

Given the expected number of children in each community, the design effect was just under 3.0. It was thus estimated that at most 120 children would be required in each of the study arms (control (Non-Pool) and intervention (Pool) communities). This was exceeded substantially in the ensuing research. The project therefore clearly had sufficient power to test all outcome measures.





Statistical analyses

Standard statistical tests were used for categorical variables (chi-square test). Regression modelling was undertaken for multivariate analysis. This included using a generalized linear model with allowance for clustering for cross-sectional data, and appropriate generalized estimating equations for repeated measures data. Intervention dosage (i.e. pool usage) was estimated from school attendance data given the 'No school No pool' policy.

The statistical packages SPSS 16 for Windows and Stata 10 were used for all analyses.

Data entry error rate (transcriptional error rate) estimation

To obtain an estimate of the error rate of data entry into the database approximately every 10th record in the database was checked against the original data from one of the two annual visits to the APY Lands (and Yalata) for each year. This amounted to approximately 5% of records. There were minor differences in accuracy between the three casual employees who had been employed for data entry. One hundred and seventeen (117) records were checked out of a total of 2128 (5.5%)

Specifically the following data were checked (figures in parentheses indicate individual items per heading): name (2), date of birth (d.o.b.) (1), gender (1) community (1), Pool/Non-Pool (1), audiometric data (8), tympanometric data (8), medical diagnosis & recommendation (9).

Fifteen (15) transcriptional errors were detected in 3624 assessed entry items, giving an error rate of 0.41% (95% confidence limits: 0.23% - 0.68%). There were very few errors in numerical data entry (for example in audiometric thresholds). While not frequent, there were a small number of errors in assigning data to the incorrect ear (L vs R), particularly with tympanometry, and particularly in the 2009 data. Some of this was due to data entry and some to errors in the primary data.

There were twenty-one (21) 'curatorial' errors identified (eg. incompatible information, information omitted or needlessly included on forms, inconsistent recommendations), giving an estimate of 'error' rate of 0.58% (95% CI 0.36% – 0.88%).

Some considerable inconsistency in given name and family name was noted, and absence of d.o.b.. These were not included in the above curatorial error rate determination as this was prior to a final cleaning of the data by a research assistant and the inclusion of unique DECS identifiers in the database which rendered errors in names immaterial. In summary it is most unlikely that transcriptional errors would have significantly reduced the accuracy or power of any analyses.

Results

Profile of school age participants

This section of the Report details basic statistical information about numbers of children in each of the communities assessed at each visit (Table 4), the number of occasions on which individual children were assessed (Table 5), distribution of ages at first visit in Pool and Non-Pool communities (Table 6), and gender distribution at first visit in Pool and Non-Pool communities (Table 7).

TABLE 4

Numbers of children assessed in each community during the bi-annual visits (2009-2011)											
Community Visit no.	Amata	Murputja	Pipalyatjara	Watarru	Ernabella	Fregon	Mimili	Indulkana	Yalata*	Oak Valley*	Total assessed
1 Mar-09	33	25	25	-	106	16	43	45	55	18	368
2 Sep-09	53	16	21	13	82	16	43	38	39	7	328
3 Mar-10	66	19	36	-	105	23	49	60	40	6	404
4 Sep-10	37	21	-	-	95	22	43	49	38	-	305
5 Mar-11	57	15	37	12	94	28	38	53	39	-	373
6 Sep-11	53	23	35	-	77	25	26	56	36	-	331
Community total	299	119	154	25	559	130	242	301	247	31	2107

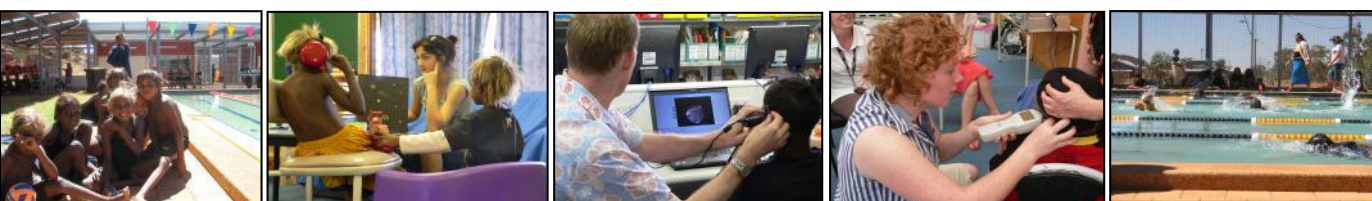
*Visits to Yalata and Oak Valley occurred in May or October (once in November due to school constraints)

Scheduled visits to Pipalyatjara and Watarru (visit 4) were prevented by impassable roads following rain

TABLE 5

TIMES ASSESSED	1	2	3	4	5	6	TOTAL
N	262	179	152	103	83	34	813
AGGREGATE assm't	262	358	456	412	415	204	2107
% CHILDREN	32.2	22.0	18.7	12.7	10.2	4.2	100

A total of 813 children were assessed between 1 and 6 times. These data do not directly reflect on school attendance as they are influenced by pipeline effects.





The data below indicate that there was no statistical difference by age in the children assessed in Pool and Non-Pool communities

TABLE 6

Visit 1: Distribution by age of children seen in Pool and Non-Pool communities

					Total		
	Non-pool communities		Pool communities		N	%	
	N	%	N	%			
Age	<=5	14	6.6	14	9.0	28	7.6
	6.00	21	9.9	14	9.0	35	9.5
	7.00	22	10.4	9	5.8	31	8.4
	8.00	18	8.5	16	10.3	34	9.2
	9.00	21	9.9	16	10.3	37	10.1
	10.00	20	9.4	18	11.5	38	10.3
	11.00	24	11.3	10	6.4	34	9.2
	12.00	17	8.0	14	9.0	31	8.4
	13.00	19	9.0	13	8.3	32	8.7
	14.00	12	5.7	12	7.7	24	6.5
	15.00	11	5.2	8	5.1	19	5.2
	16.00	7	3.3	4	2.6	11	3.0
	17.00	2	0.9	7	4.5	9	2.4
	18+	4	1.9%	1	0.6	5	1.4
Total		212	100.0	156	100.0%	368	100.0%

Chi-squared=12.569 on 13 df, p= 0.482.

Median age, IQR: No pool: Median =10.0, IQR = 6: Pool: Median = 10.0, IQR = 5.

During the entire project a small number of children <5y and >18y enrolled in the schools were also tested. These constituted 2.4% of the final sample.

The data below indicate that there was no statistical difference by gender in the children assessed in Pool and Non-Pool communities.

TABLE 7

Visit 1: Distribution by gender of children seen in Pool and Non-Pool communities

						Total	
		Non-Pool communities		Pool communities		N	%
		N	%	N	%		
Gender	Female	115	54.2	90	57.7	205	55.7
	Male	97	45.8	66	42.3	163	44.3
Total		212	100.0	156	100.0	368	100.0

Chi-squared=0.433 on 1 df, p= 0.511

No ensuing statistically significant differences of these population descriptors were observed for Pool and Non-Pool populations at subsequent visits.

Hearing Test (Audiometric) Outcomes

In order to pass the screening hearing test a child was required to respond to a 20dBHL tone at all 4 test frequencies (0.5, 1.0, 2.0 & 4.0kHz) in each ear. A high proportion of children failed the screening test. In Pool communities 70.5% of children failed the screening test; in Non-Pool communities 68.2% of children failed the hearing screening test (NS) (Table 8).

No statistical difference was observed between Pool and Non-Pool communities in the percentage of children failing (Table 9)

TABLE 8

Screening test results for children in Pool and Non-Pool communities for each visit

Visit	Non-Pool communities				Pool communities				Sig.*
	Pass		Fail		Pass		Fail		
	N	%	N	%	N	%	N	%	
1	62	29.5	148	70.5	43	27.7	112	72.3	0.710
2	52	30.6	118	69.4	48	30.8	108	69.2	0.972
3	55	25.9	157	74.1	49	25.5	143	74.5	0.923
4	67	35.8	120	64.2	47	39.8	71	60.2	0.482
5	61	30.3	140	69.7	46	26.9	125	73.1	0.464
6	67	37.2	113	62.8	41	27.3	109	72.7	0.057

*Based on chi-squared test

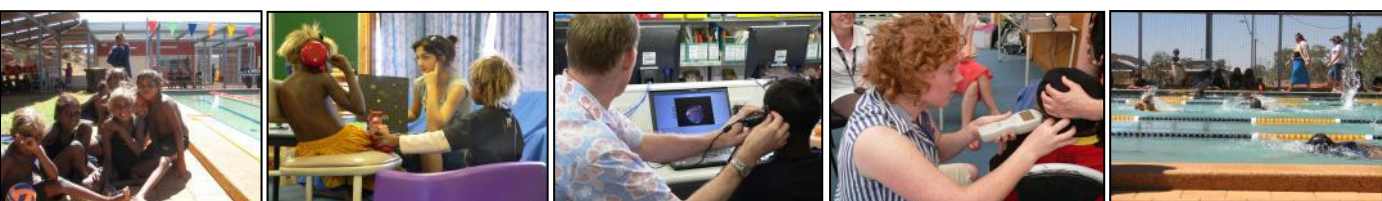




TABLE 9

Relative risk of hearing screening failure for Pool versus Non- Pool communities

Visit	Pool		Sig.*
	RR	95% CI	
1	1.02	0.95 – 1.11	0.544
2	1.00	0.85 – 1.17	0.974
3	1.01	0.83 – 1.22	0.953
4	0.94	0.83 – 1.06	0.288
5	1.05	0.93 – 1.19	0.452
6	1.16	1.02 – 1.32	0.025
Combined	1.03	0.95 – 1.12	0.431**

*Based on log binomial GLM adjusted for clustering by community

**Based on log binomial GLM adjusted for clustering by participant ID

As bilateral ear pathology may represent more severe disorder than unilateral pathology the hearing data were analysed to test for any difference between Pool and Non-Pool communities in this aspect of the hearing screening results. No significant difference was observed (Tables 10 and 11).

TABLE 10

Screening test results for unilateral and bilateral Pass rates for children in Pool and Non-Pool communities by visit.

Visit	Non-Pool communities						Pool communities						Sig.*
	FAILED SCREENING TEST AT >20dB												
	Passed		Unilateral fail		Bilateral fail		Passed		Unilateral fail		Bilateral fail		
	N	%	N	%	N	%	N	%	N	%	N	%	
1	63	30.0	53	25.2	94	44.8	43	27.6	50	32.1	63	40.4	0.357
2	54	31.4	56	32.6	62	36.0	49	31.4	38	24.4	69	44.2	0.193
3	55	25.9	51	24.1	106	50.0	48	25.1	41	21.5	102	53.4	0.761
4	68	36.6	47	25.3	71	38.2	48	40.7	29	24.6	41	34.7	0.754
5	61	30.3	47	23.4	93	46.3	46	26.9	41	24.0	84	49.1	0.578
6	68	37.8	39	21.7	73	40.6	44	29.3	41	27.3	65	43.3	0.228

*Based on Chi-squared test

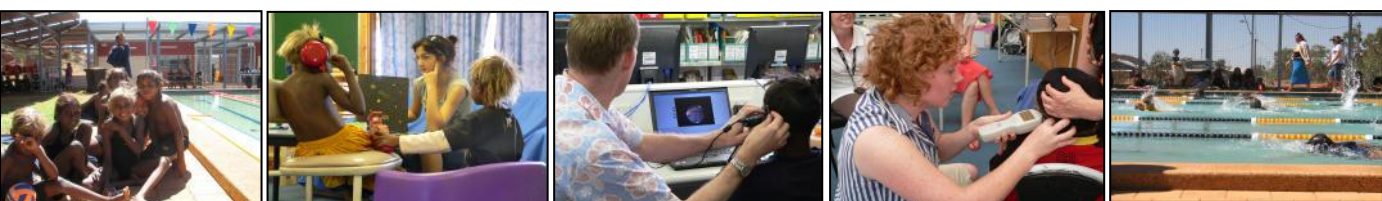
TABLE 11

Odds ratio of changing one category higher (Pass>Unilateral Fail>Bilateral Fail) for Pool communities versus Non-Pool communities at each visit

Visit	Pool		Sig.*
	OR	95% CI	
1	0.94	0.68 – 1.31	0.728
2	1.21	0.80 – 1.83	0.360
3	1.11	0.58 – 2.12	0.750
4	0.85	0.60 – 1.20	0.362
5	1.14	0.84 – 1.55	0.389
6	1.26	0.83 – 1.92	0.284
Combined	1.10	0.86 – 1.39	0.450**

*Based on ordinal logistic regression adjusted for clustering by community

** Based on ordinal logistic regression adjusted for clustering by ID





Ambient Noise as a potential confounding factor for Pass/Fail in hearing screening

To reduce the possibility that low frequency ambient noise may have contributed to a falsely high fail rate on the screening test the data were re-analysed using a less stringent criterion in which failure required a 4 frequency pure tone average greater than or equal to 25dBHL. Under this condition 45.7% of Non-Pool community children passed the screening hearing test and 42.3% of children from Pool communities passed the screening hearing test (NS). The data are presented in Table 12.

TABLE 12:

Screening test results by visit for unilateral and bilateral Pass rates for children in Pool and Non-Pool communities at the less stringent criterion for failure.

Visit	Non-Pool communities						Pool communities						Sig.*
	FAILED SCREENING TEST AT \geq 25dB												
	Passed		Unilateral fail		Bilateral fail		Passed		Unilateral fail		Bilateral fail		
	N	%	N	%	N	%	N	%	N	%	N	%	
1	88	41.9	57	27.1	65	31.0	63	40.4	46	29.5	47	30.1	0.357
2	79	45.9	52	30.2	41	23.8	64	41.0	44	28.2	48	30.8	0.193
3	87	41.0	51	24.1	74	34.9	72	37.7	45	23.6	74	38.7	0.761
4	93	50.0	49	26.3	44	23.7	66	55.9	28	23.7	24	20.3	0.754
5	88	43.8	58	28.9	55	27.4	69	40.4	44	25.7	58	33.9	0.758
6	95	52.8	42	23.3	43	23.9	64	42.7	44	29.3	42	28.0	0.228

*Based on Chi-squared test

TABLE 13

Odds ratio of changing one category higher (Pass>Unilateral Fail>Bilateral Fail) for Pool communities versus Non-Pool communities at each visit (less stringent criterion for Fail)

Visit	Pool		Sig.*
	OR	95% CI	
1	1.02	0.70 – 1.48	0.918
2	1.29	0.85 – 1.96	0.224
3	1.16	0.80 – 1.69	0.426
4	0.80	0.61 – 1.04	0.094
5	1.24	0.83 – 1.84	0.295
6	1.40	0.90 – 2.18	0.125
Combined	1.16	0.91 – 1.47	0.222**

*Based on ordinal logistic regression adjusted for clustering by community

** Based on ordinal logistic regression adjusted for clustering by ID

As previously, there was no difference between children in Pool and Non-Pool communities based on potential severity of hearing loss based on the presence of unilateral or bilateral failure of the screening test (Table 13) at the second, less stringent, screening criterion.

Tympanometric outcomes

Tympanometry provides a number of discrete measures of the tympanic membrane and middle ear function, but for the purpose of this study those measures which indicate the likely presence of fluid in the middle ear, behind an intact tympanic membrane (i.e. otitis media with effusion (OME)) are the most relevant. This is referred to as a 'Type B tympanogram'. The absence of Type B tympanograms or the unilateral or bilateral presence of Type B tympanograms is given in Table 14 for each visit. As bilateral ear pathology may represent more severe disorder than unilateral pathology the tympanometric data were analysed to test for any difference between Pool and Non-Pool communities in this aspect of the tympanometry results (Table 15). There was no evidence of a differing risk for closed ear disease as seen in Type B tympanograms associated with Pool and Non-Pool communities.

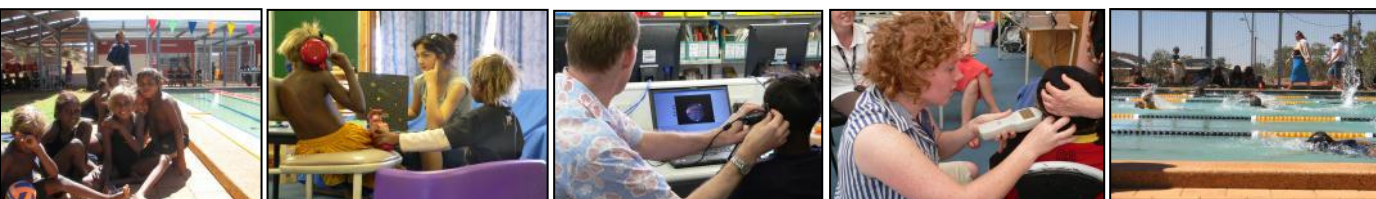




TABLE 14

Results by visit for absent Type B tympanograms (normal condition) or unilateral or bilateral type B tympanograms for children in Pool and Non-Pool communities.

Visit	Non-Pool communities						Pool communities						Sig.*
	Abnormal tympanometry Type B						Abnormal tympanometry Type B						
	none		unilateral		bilateral		none		unilateral		bilateral		
	N	%	N	%	N	%	N	%	N	%	N	%	
1	135	64.3	47	22.4	28	13.3	97	62.2	32	20.5	27	17.3	0.563
2	119	69.2	32	18.6	21	12.2	102	65.4	36	23.1	18	11.5	0.608
3	140	66.0	53	25.0	19	9.0	141	73.8	29	15.2	21	11.0	0.049
4	137	73.7	30	16.1	19	10.2	91	77.1	16	13.6	11	9.3	0.783
5	133	66.2	48	23.9	20	10.0	113	66.1	38	22.2	20	11.7	0.830
6	119	66.1	39	21.7	22	12.2	96	64.0	30	20.0	24	16.0	0.606

*Based on Chi-squared test

TABLE 15

Odds ratio of changing one category higher (none>unilateral Type B> bilateral Type B tympanogram) for Pool communities versus Non-Pool communities

Visit	Pool		Sig.*
	OR	95% CI	
1	1.14	0.70 – 1.86	0.591
2	1.15	0.76 – 1.74	0.516
3	0.74	0.48 – 1.14	0.178
4	0.84	0.49 – 1.43	0.518
5	1.03	0.52 – 2.03	0.934
6	1.14	0.65 – 2.02	0.649
Combined	1.01	0.78 – 1.30	0.967

*Based on ordinal logistic regression adjusted for clustering by community

** Based on ordinal logistic regression adjusted for clustering by ID

Perforation of the tympanic membrane

Active Mucosal Chronic Otitis Media ('wet perforation')

Middle ear pathology was assessed and diagnosed by direct visualisation using standard otoscopy and/or video-otoscopy. Approximately 80% of assessments were undertaken by an ENT surgeon or ENT registrar (trainee) *in situ* on the APY Lands and in Yalata. The remainder of assessments were made by ENT surgeons on return to Flinders University based on review of video-otoscopic records. Indigenous children in remote Australia have an exceptionally high prevalence of perforation of the eardrum which may display active disease in the ME (active mucosal chronic otitis media, sometimes referred to as chronic suppurative otitis media (CSOM) and commonly referred to as a 'wet perforation'). Where there is no active infection in the presence of a perforation of the ear drum the condition is referred to as inactive mucosal chronic otitis media. This is indicative of past active ME infection and is commonly referred to as a 'dry perforation'. Perforations may oscillate between dry and wet with reinfection. Other causes of perforation include trauma. However there was no instance in which there was reason to believe that a perforation of the tympanic membrane had been due to a cause other than a ME infection.

Table 16 displays the data obtained on the number and percentage of children in Non-Pool communities and Pool communities at each visit who had no wet perforation or had unilateral or bilateral wet perforations. The data in Table 16 demonstrates that there is no difference between the children in Pool and Non-Pool communities in the frequency with which perforations with active ear disease are present. Table 17 demonstrates that, to the extent that bilateral wet perforations may represent more severe disorder than unilateral wet perforation, there is also no difference in severity between children in Pool and Non-Pool communities.

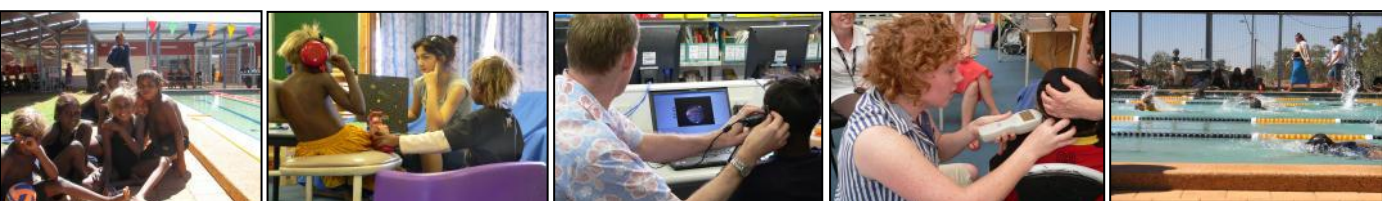




TABLE 16

Results by visit for presence of unilateral or bilateral chronic suppurative otitis media (wet perforation) or its absence in children in Pool and Non-Pool communities.

Visit	Non-Pool communities						Pool communities						Sig.*
	Wet perforations						Wet perforations						
	none		unilateral		bilateral		none		unilateral		bilateral		
	N	%	N	%	N	%	N	%	N	%	N	%	
1	165	78.6	25	11.9	20	9.5	124	79.5	21	13.5	11	7.1	0.661
2	152	88.4	14	8.1	6	3.5	134	85.9	17	10.9	5	3.2	0.692
3	160	75.5	26	12.3	26	12.3	142	74.3	29	15.2	20	10.5	0.629
4	167	89.8	16	8.6	3	1.6	105	89.0	9	7.6	4	3.4	0.583
5	152	75.6	32	15.9	17	8.5	121	70.8	29	17.0	21	12.3	0.432
6	156	86.7	15	8.3	9	5.0	129	86.0	11	7.3	10	6.7	0.778

*Based on Chi-squared test

TABLE 17

Odds ratio of changing one category higher (none>unilateral wet perforation> bilateral wet perforation) for Pool communities versus Non-Pool communities

Visit	Pool		Sig.*
	OR	95% CI	
1	0.92	0.70 – 1.22	0.572
2	1.23	0.64 – 2.36	0.526
3	1.03	0.64 – 1.65	0.905
4	1.11	0.43 – 2.86	0.833
5	1.31	0.81 – 2.11	0.271
6	1.07	0.47 – 2.44	0.863
Combined	1.12	0.83 – 1.52	0.448**

*Based on ordinal logistic regression adjusted for clustering by community

** Based on ordinal logistic regression adjusted for clustering by ID

Inactive Mucosal Chronic Otitis Media ('dry perforation')

Table 18 displays the data obtained on the number and percentage of children in Non-Pool communities and Pool communities at each visit who had no dry perforation or had unilateral or bilateral dry perforations. The data in Tables 18 and 19 demonstrate that there is no difference between Pool and Non-Pool communities in the frequency of ears having perforations with inactive ear disease.

TABLE 18

Results by visit for presence of unilateral or bilateral dry perforation or its absence in children in Pool and Non-Pool communities.

Visit	Non-Pool communities						Pool communities						Sig.*
	Dry perforations						Dry perforations						
	No dry perf		Unilateral		Bilateral		No dry perf		Unilateral		Bilateral		
	N	%	N	%	N	%	N	%	N	%	N	%	
1	165	78.6	29	13.8	16	7.6	122	78.2	25	16.0	9	5.8	0.688
2	127	73.8	27	15.7	18	10.5	116	74.4	23	14.7	17	10.9	0.967
3	176	83.0	31	14.6	5	2.4	161	84.3	24	12.6	6	3.1	0.757
4	133	71.5	38	20.4	15	8.1	94	79.7	18	15.3	6	5.1	0.270
5	162	80.6	26	12.9	13	6.5	144	84.2	23	13.5	4	2.3	0.154
6	138	76.7	36	20.0	6	3.3	121	80.7	23	15.3	6	4.0	0.532

*Based on Chi-squared test

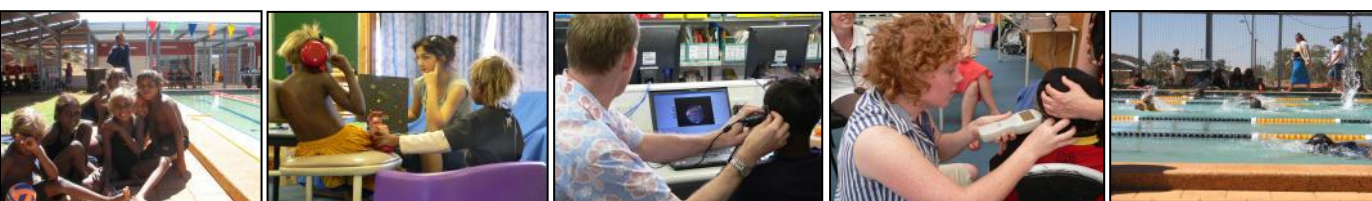
TABLE 19

Odds ratio of changing one category higher (none>unilateral dry perforation> bilateral dry perforation) for Pool communities versus Non-Pool communities.

Visit	Pool		Sig.*
	OR	95% CI	
1	1.00	0.60 – 1.66	0.990
2	0.98	0.64 – 1.52	0.935
3	0.92	0.35 – 2.44	0.870
4	0.64	0.40 – 1.03	0.064
5	0.75	0.52 – 1.09	0.133
6	0.80	0.45 – 1.44	0.460
Combined	0.84	0.61 – 1.15	0.272**

*Based on ordinal logistic regression adjusted for clustering by community

** Based on ordinal logistic regression adjusted for clustering by ID





Given that the natural history of perforations is that there will be transitions between wet and dry perforations (and *vice versa*), the same analysis was carried out for all perforations (data not shown). This was a formality given the results in Tables 16-19. There was no difference between Pool and Non-Pool communities in the frequency of combined wet and dry perforations (Combined Odds Ratio Pool communities: Non-Pool communities: 0.95 (95% CI: 0.71 – 1.27 p = 0.736 (based on ordinal logistic regression adjusted for clustering by ID)).

School Attendance and Pool Use

The Anangu schools (APY Lands, Yalata and Oak Valley) maintain school attendance data which was available for the great majority of children (it was unavailable for a few, mostly itinerant, children).

The possibility that the ‘No school No pool’ policy in place in all Pool communities may have had an impact on school attendance was assessed. Table 20 displays the median school attendance (%) and range (%) in Pool and Non-Pool communities (anonymised). The median attendance rate in the two study arms was: Non-Pool communities (75.3%) and Pool communities (73.9%). A student’s t-test adjusted for clustering by community and allowing for a skewed distribution by using a robust error term found this difference to not be statistically significant (p=0.994). [Attendance for Community E was unavailable for 2009 which is reflected in the different value for that school.] These data suggest that in communities where a pool exists there has been no consequential increase in school attendance.

TABLE 20

Three year median school attendance by community

Community	Study arm	Number of students	Median School attendance (%)	Range (%)
C	Pool	248	73.1	82.9
D	Pool	128	74.7	81.4
F	Pool	215	79.2	70.0
B	Pool	222	68.1	92.7
E	No pool	22	42.5	52.2
G	No pool	107	78.0	76.1
H	No pool	16	83.6	39.0
A	No pool	516	75.6	79.5
I	No pool	105	70.9	78.6
J	No pool	263	76.6	82.9

School attendance as an effect modifier on hearing and ear drum perforation

In the absence of records of individual student use of pools in Pool communities, school attendance was assessed as an effect modifier. When assessing Pool communities and Non-Pool communities for hearing screening failure using the statistical model but including an interaction term for school attendance there is no evidence that school attendance moderates the relationship between a community having a pool or not and children failing the screening hearing test ($p=0.906$).

When assessing Pool and Non-Pool communities for middle ear pathology (eardrum perforation) using the same interaction term for school attendance there is no evidence of school attendance being a moderator ($p=0.942$).

Age as an effect modifier on hearing and ear drum perforation

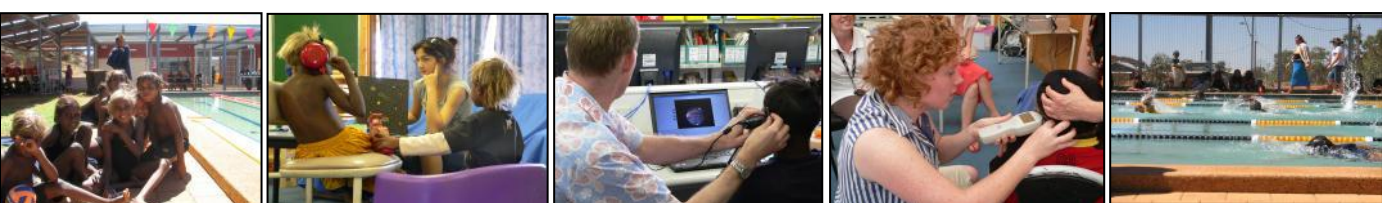
As reported by one School Principal ($p.28$) there is a belief that pool usage by primary school children exceeds that of secondary school children. Accordingly for further analysis school children were categorised into two age groups 5-12 years (Primary School) and 13-18 years (Secondary School). The statistical model was tested for failing a hearing screening test and (separately) for having a middle ear pathology (eardrum perforation), including age as an interaction term. Age does not moderate the relationship between a community having a pool and a child failing the screening hearing test ($p=0.416$).

There is a significant interaction effect of age for eardrum perforation, that is age does appear to be a moderator of ear drum perforation ($p=0.034$). However when stratified by age group (as defined above) the relationship between a community having a pool and the probability of middle ear pathology (ear drum perforation) is not statistically significant (for children 5 – 12 years: $p=0.682$, for children 13 – 18 years: $p=0.297$). The direction of association is that having a pool appears to protect to a greater extent in older children than in younger children.

Both these regression models are based on substantial sample sizes and are unlikely to be underpowered. We can think of no plausible explanation as to why the protective effect is stronger in the older children and in both regression models the pool effect was not statistically significant.

The issue of dosage as an effect modifier

As indicated above, occasions of pool usage ('dosage') by individual children were not available. However a surrogate of this, school attendance, was used as a quantitative measure for children's exposure to pools in Pool communities. The absence of any effect on hearing or ear health of this surrogate measure of dosage formally leaves the possibility that either:





(i) the extent of pool usage by children in Pool communities was insufficient to permit any beneficial aspect of pools for ear health to be measured,

or

(ii) the effect of pools is so great that the infrequent use of pools by children in Non-Pool communities provides benefits equal to children resident in Pool communities.

These alternatives are mutually exclusive. If alternative (ii) was to apply then improvements in ear health and hearing would be expected across the APY Lands following the introduction of the first swimming pool in 2006. The authors' published work (Sanchez et al., 2010) shows no such evidence: for example, the frequency of children on the APY Lands with one or more perforations of the ear drum in the period 2003 – 2008 was 37%. In the present study (2009 – 2011) the frequency was 36.1% (NS). The former alternative (i) invites the prospect that swimming pools are, *a priori*, beneficial for ear health and hearing. We have no evidence for this and it is difficult to imagine how increased use of pools could be mandated. Given that the research described here, through its very large number of participants and its high retention rate, has had exceptional statistical power, it is unlikely that further studies could generate different results.

Summary comments on results of the investigations of associations between access to swimming pools and hearing, ear health and school attendance

The approved detailed Research Plan has been completed with only minor variations and with participant numbers greatly exceeding those necessary to test the hypotheses (with statistical power (80%) for a level of statistical significance of 0.05) that Swimming Pools in remote communities on the APY and Yalata Lands provide a number of benefits for the ear health and hearing of Indigenous school age children.

The sample population was large and, in comparison with other longitudinal studies with Indigenous children, the 'retention' as measured by frequency of testing individual children over the 6 visits was unusually high (Table 5 and Appendix 4). The two arms of the study, children in Pool communities and children in Non-Pool communities, were very well matched by age and gender (Tables 6 & 7).

The findings demonstrate that access to swimming pools does not result in improvement in any of the measured indices of hearing or ear health. Additionally there is no evidence that access to a swimming pool results in improved school attendance.

Specifically there is:

- i. no significant difference between children in Pool communities and Non-Pool communities in the hearing screening (audiometric) pass or fail rates (unilateral or bilateral) either at a pure tone average of 20dBHL or at the less stringent criterion of no threshold at any frequency ≥ 25 dBHL (Tables 8-13).
- ii. no significant difference between children in Pool communities and Non-Pool communities in the percentage of children with Type B tympanograms (unilateral or bilateral), indicative of closed middle ear disease (middle ear fluid) (Tables 14 & 15).
- iii. no significant difference between Pool communities and Non-Pool communities in the percentage of children in these communities who have either 'wet' or 'dry' perforations of the tympanic membrane (eardrum) consequential to middle ear disease (Tables 16 – 19).
- iv. additionally there is no significant difference between Pool communities and Non-Pool communities in median school attendance (Table 20).





Important findings relevant to middle ear disease and hearing in Anangu children not related to swimming pools

Although the Swimming Pool Research Project has not identified any measurable effect of access to SP on the incidence of middle ear disease or hearing loss it has provided a rich source of information on the natural history of middle ear disease in school children on the APY Lands and in Yalata and Oak Valley. A detailed study of the natural history of ear pathology in individual children, which may significantly inform future clinical practice, is beyond the scope of this report. Nonetheless there are some population measures of the natural history of middle ear disease which can be reported here.

Seasonal variation in wet and dry perforations

As can be seen in Figs. 3 and 4, there are major differences in the frequency of wet and dry perforations according to season. At the end of summer (March) there is a higher frequency of wet perforations than at the end of winter (September). This applies to both the absolute number of perforated ears (Fig. 4) and the number of children with wet perforations (Fig. 3). Conversely there is an increase in the proportion of dry perforations (as assessed by ears and children) at the end of winter compared to the end of summer. Most likely this is largely due to transitioning from inactive to active ME disease (dry to wet perforation) through re-infection of the exposed ME mucosa during the summer period. However there is an increase in total perforations seen at the end of summer indicative of new, and principally wet, perforations, arising during the spring and summer seasons.

As shown in Table 21 a log binomial generalised model with clustering demonstrates that:

- with respect to wet perforations, children were 1.96 times more likely to have at least one wet ear at the end of summer than at the end of winter (considering all communities).
- with respect to wet perforations, the risk ratios in Pool and Non-Pool communities indicate that the greater prevalence of wet ears at the end of summer is not influenced by swimming pools.
- with respect to dry perforations, children were 24% less likely to have at least one dry ear at the end of summer than at the end of winter (considering all communities).
- with respect to dry perforations, the risk ratios in Pool and Non-Pool communities indicate that the lower prevalence of dry ears at the end of summer is not influenced by swimming pools. [The direction of change and similarity of risk ratio favour this interpretation despite the reduction in prevalence being statistically significant for Non-Pool communities but not achieving significance for Pool communities.]

FIGURE 3

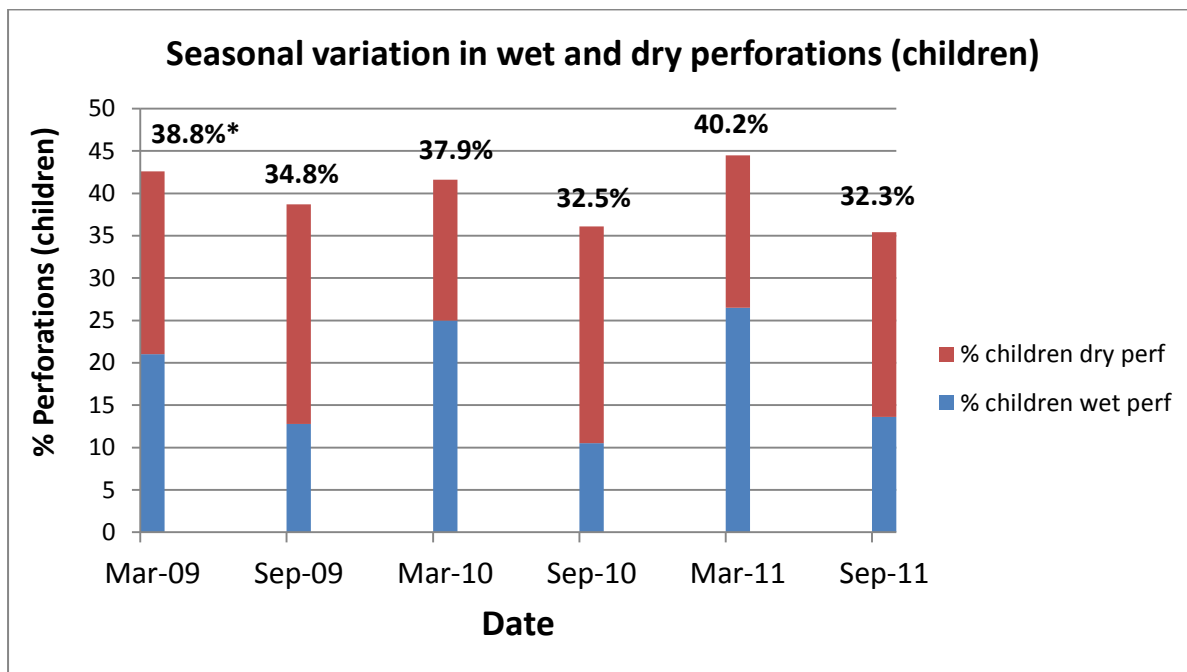


FIGURE 4

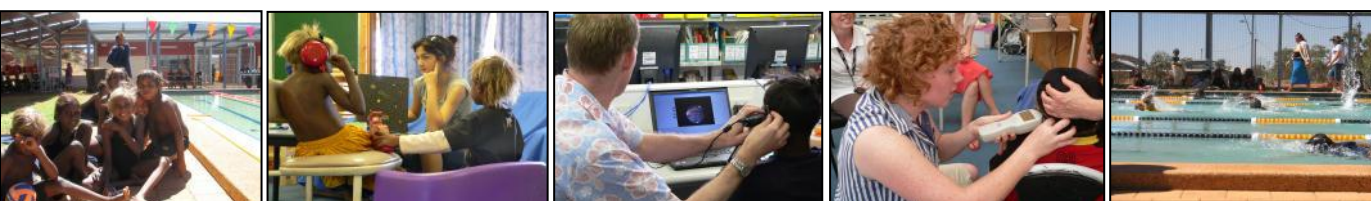
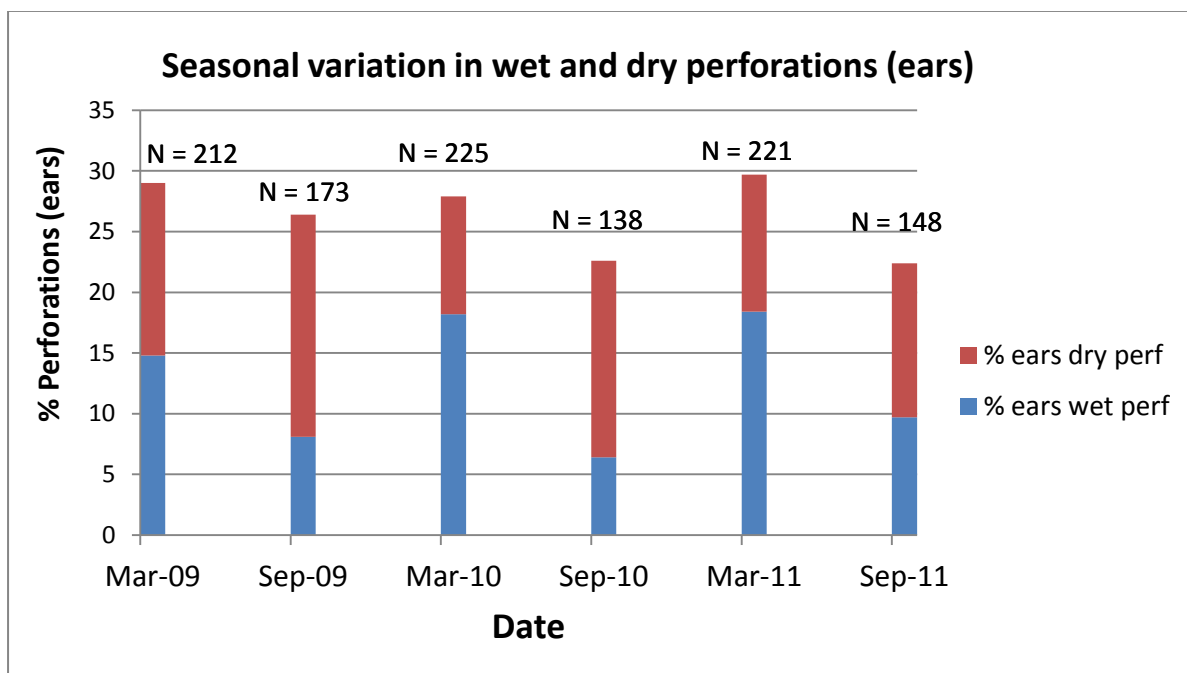




TABLE 21

Seasonal effect on perforations¹: relative risk of perforation at end of summer compared to end of winter.

perf type	community	risk ratio	std.err.	Z	P> Z	95% CI
wet	All	1.963	0.171	7.77	<0.001	1.66 – 2.33
	Pool	1.915	0.313	3.97	<0.001	1.39 – 2.64
	Non-Pool	2.001	0.206	6.75	<0.001	1.64 – 2.45
dry	All	0.764	0.094	-2.19	0.029	0.60 – 0.97
	Pool	0.801	0.240	-0.74	0.459	0.44 – 1.44
	Non-Pool	0.740	0.045	-4.92	<0.001	0.66 – 0.83

¹ log binomial generalised linear model with clustering by community

Discussion

These data on seasonal variation of eardrum perforation are important as they challenge the interpretation of data published by Lehmann et al.(2003) which has been widely cited as evidence of swimming pools in remote communities reducing the prevalence of dry perforation (in their study changes in wet perforations did not achieve significance). Lehmann *et al.* infer a causative role for saltwater chlorinated swimming pools in a reduction of perforations in 2 remote communities in Western Australia with climatic conditions similar to those found in the APY Lands. Lehmann et al. did not have control communities without pools. They examined small numbers of Indigenous children (54) in the first survey prior to the pools being opened which was a low number of baseline assessments against which to measure change. Children (N=162) were assessed for 18 months following the opening of the swimming pools. Their results show similarity to the statistically robust seasonal effects we report here based on very large numbers of children (at least fivefold greater than that of Lehmann et al.). Lehmann et al. report levels of wet perforations higher in the 2 summer visits than in the one winter visit and increases in dry perforations in winter. A subsequent publication (Lehmann et al., 2010), which did not specify participant numbers, also broadly shows the same seasonal changes over a longer period. In view of the seasonal data presented in this report, and the absence of control communities in the report of Lehmann et al.,(2003) their conclusion that swimming pools were associated with reduction in tympanic membrane perforation is unsafe. It seems likely that a Type 1 error was made.

In the HPE/DHA Report (2010) the authors noted “a difference in the distribution of wet and dry perforations between the first and subsequent visits. This is most likely due to the fact that a different team of doctors was used to do the otoscopic examinations for the first visit compared to the second, third and fourth visits (where the same team were utilised). This may have led to a misclassification in the type of perforation given the combined rate of wet

and dry perforations was about the same for the four visits.”(page 12). While this explanation cannot be ruled out the authors did not consider the possibility of a seasonal effect as described here and which we consider an alternative explanation.

Age associated variations in hearing loss and size of dry perforation in Anangu children

Perforation of the eardrum generally results in impaired hearing. Wet perforations will generally result in greater hearing loss for an equivalent size perforation than will be found for a dry perforation as the presence of fluid/discharge will provide an additional mechanical damping on the transmission of sound vibrations to the cochlea (inner ear).

The data presented in Figure 5 demonstrate that both wet and dry perforations present in children on the APY Lands result in significant hearing loss. Wet perforations, on average, are associated with a greater hearing loss, as expected. The data also demonstrate that for dry perforations there is a highly significant association between increasing age and increasing hearing impairment as measured by the 4 frequency pure tone average (4F PTA), ($p < 0.0017$ and Fig 5 legend). Taken together with the aggregate numbers of children with perforations (Figs. 3 and 4), these data (Fig. 5) indicate an appalling level of hearing disability among Anangu children with indisputable consequences for educational and social development.

As part of the medical diagnosis an estimate of the size of each perforation was made with classification as: $<25\%$ of the area of the tympanic membrane (TM), $25\% - 50\%$ of the area of the TM, or $>50\%$ of the TM. The magnitude of the hearing loss (4F PTA) is also highly correlated with an increase in size of dry perforations (4F PTA dry perf: correlation with perforation size: $r = 0.23$: $df = 559$: $p < 0.0001$).

Discussion

It is important to note that a large percentage of the larger dry perforations would be unlikely to spontaneously repair and would have a significant probability of becoming re-infected (transition to a wet perforation) with ongoing and worsening outcomes for hearing. In urban Australia the great majority of equivalent dry perforations would be surgically corrected (myringoplasty) with a high degree of success and with the expectation of restoration of hearing to within normal limits.

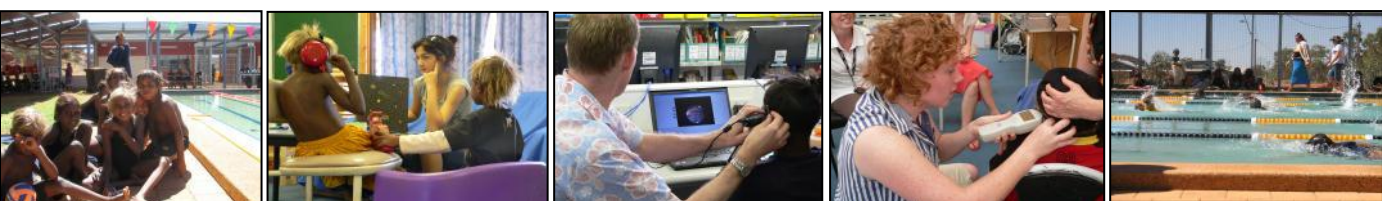
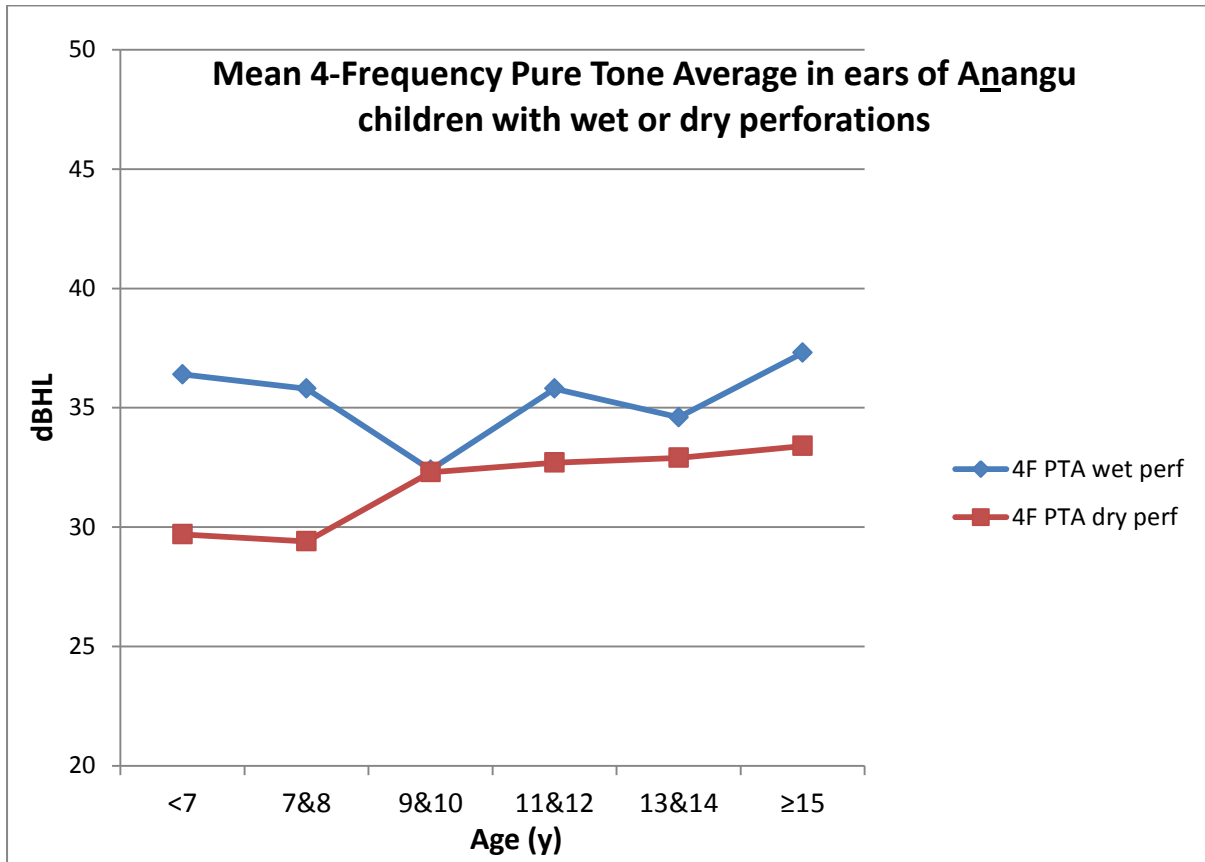




FIGURE 5



4F PTA dry perf: correlation with age: $r = 0.13$: $df = 560$: $p < 0.0017$

Dissemination of the research results and research transfer

The dissemination of the results of this research project will occur after final approval and clearance of the report by the DHA (mid 2012). Dissemination methods and activities overlap with the concept and practices of research transfer and are considered together below. Research transfer is defined by the Lowitja Institute (2009) as “getting knowledge and information out into the community and into use by health services, governments and others. This means ensuring the research is done in a way that makes it most likely to be relevant and of use - and to be used - to inform and bring about positive change.”

Although the major results of the SP project can only be disseminated after its formal conclusion, there has been sustained promotion of and publicity for the research project and sharing of some of the interim research data throughout the project. This has occurred at the community level with formal and informal sharing of the clinical results for individual children with the schools, the two health services and Australian Hearing and with individual families and teachers when we were approached for information. We also maintained a high profile for the project among health and education professionals, government and the general public. These activities, in the form of presentations, submissions to government, responses to requests for the use of our data and media contact have continued to draw attention to the very high prevalence of middle ear disease and conductive hearing loss in Anangu children and the need for multiple types of intervention to address the issue. These activities are detailed in Appendix 1. They cover a number of the research transfer activities recommended by the Lowitja Institute, as do the majority of the post-project activities detailed below.

Planned dissemination of the research results

Information and discussion sessions with Anangu in community

Priority will be given to informing the research participants, namely the Anangu people in the communities on the APY, Yalata and Maralinga Tjarutja Lands, about the research results and what we see as their implications. We will present the results with the suggestion to community members that they may wish to use them as a basis for the development of community driven initiatives in ear health and hearing. This feedback will be given during a final, research-funded visit to the main communities by the investigators and project officer. This is scheduled for early November 2012.

We will enlist the help of the AES and the school principals in all communities to enable us to promulgate our work and results. In the first instance we will meet with the PYEC and the Leaders Meeting (School Principals and senior education administrative staff of the AES and inform them of our results using a visually rich PowerPoint presentation which will include video segments.





We will request the assistance of an interpreter to help with the feedback session to the PYEC. In addition we will have access to approximately 30 minutes worth of recorded oral material on the topic of ear disease and hearing loss in Anangu children and also specifically about the results of the SP study. This material is the content of two radio interviews with the chief investigator recorded on the Paper Tracker Radio Show. One interview was recorded in February 2012 and the second is scheduled to be recorded prior to November 2012. All the material in these radio interviews is translated during the show's recording into Pitjantjatjara by co-presenter, Ms. Rose Lester. These recordings will be edited to provide support material in Pitjantjatjara for our in-country feedback and will be available on line.

The two radio programs in themselves are an important vehicle for the research dissemination. (See Media section below)

As the SP project was a collaborative project with the AES and the data collection in its entirety was carried out in the community schools, we expect the AES staff, comprising principals, teachers and Aboriginal Education Workers (AEWs) will also wish to attend the feedback sessions. PYEC members live in various communities and will be invited to the sessions as will members of the local swimming pool committees in the Pool communities.

In the past 5 years a large amount of Australian produced health promotion and education and training materials focusing on Aboriginal ear disease has been created. Most of it is readily accessible at low or no cost. Some of these materials will be used and promoted in our research dissemination efforts in order to publicise their availability and increase their uptake among the target groups in these remote communities.

Dissemination of results to other key groups and in different formats

Health services in the two regions

Discussions with the medical directors of each health service will help to determine the best format for feedback to their staff. With sufficient notice of the community meetings, some health workers, particularly the community nurse practitioners and the Aboriginal Health Workers (AHWs) may be able to attend those meetings. A Plain English summary handout will be developed.

The health sector community in South Australia and other relevant States and Territories

Target stakeholders will be policy units, health promotion units, and health service delivery organisations. Dissemination will be via a copy of this Report in hard copy and more widely by reference to the DHA website.

State and Federal politicians and peak government organisations

Dissemination will be via a copy of the Executive Summary and Recommendations of this report and reference to the DHA website.

Media releases

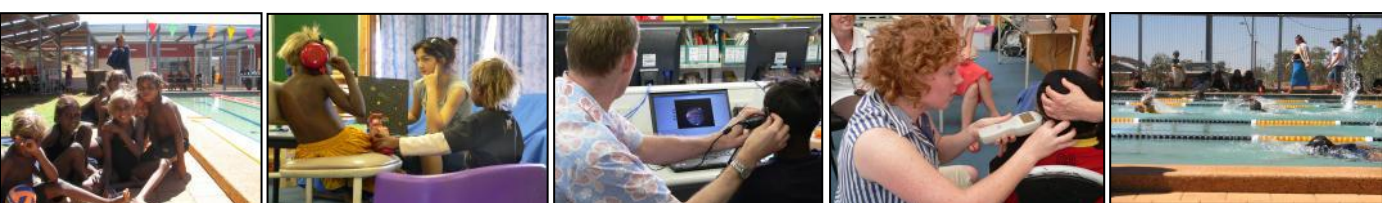
Media interest is likely to be muted given the study's finding of no relationship between SP use and improvements in ear health and hearing in Aboriginal children in remote SA. Nonetheless it is important for this finding and others to be actively promulgated to remote Indigenous communities in Central Australia. It will be a priority to use such indigenous media as: the Paper Tracker Radio Show, the web based Anangu Paper Tracker, Umeewarra Radio (SA's only Aboriginal radio station based in Port Augusta) and Imparja Television and Radio based in Alice Springs. We will seek assistance from Flinders University's Media unit to optimise the media contacts. Dissemination via the Paper Tracker Radio Show is already in hand (see above).

Mainstream academic forums

Avenues for dissemination of research include professional and multi-disciplinary journals, national and international conferences, the Lowitja Institute website, the specialist website: Indigenous EarInfoNet, (part of the HealthInfoNet website).

The SP research already has a website presence on the Lowitja Institute's website and this will be updated.

The investigators will publish results of the SP project in peer-reviewed journals within the next 1-2 years.





Research transfer

We expect the most powerful feature of the research results that will enhance their relevance to the Anangu will be that the results, in their entirety, relate to them, their children and their communities. The information also has the potential “to inform and bring about positive change” (Lowitja Institute, 2009).

The emphasis of the feedback of the results to Anangu, whatever the medium, will be on hearing rather than ear disease. Hearing loss is the disability caused by OM and the disability is recognised as huge, if still relatively under-quantified in terms of its impact on children developmentally and educationally. An emphasis on hearing will support a future focus on both the health and education of Anangu children and the development of initiatives in and across both the health and education sectors to address the issues.

While good hearing is important to all children for strong cognitive, language and social development and successful education, it can be argued that good hearing has additional importance to Indigenous families and children living in more traditional remote communities. Good hearing supports the transmission of oral culture by means of narrative, music and song from elders to young people. Further, good hearing from infancy optimises the child’s ability to learn the first language of the community and to be confident in that language before acquiring English as a second language. This is highly relevant to the Anangu because of the robustness and widespread use in Central Australia of their Pitjantjatjara and Yankunytjatjara languages.

Appendix 1: Dissemination and Research Transfer Activities arising from the project 2009-2012

2009

McFarlane, T., Carney, AS, Sanchez, L., Swimming Pools research project, presentation to the ASOHNS (SA) Trainees Research Day, November, 2009.

Sanchez, L., invited contribution to the Sir Ewan Waterman seminar on Social Accountability in the School of Medicine, Hearing and Ear Health in Children in the Pitjantjatjara Lands, 22 October 2009.

Sanchez, L., Submission to the Senate Enquiry into Hearing Health in Australia, Focus: Indigenous Ear Health and Hearing, October, 2009.

2010

McFarlane, T., Sanchez, L., Sparrow, K., Choo, J., Turner, D., Carney, A.S., The impact of swimming pools on the hearing and middle ear health in school age Aboriginal children, ASOHNS Annual Scientific Meeting, 29 March, 2010, Sydney.

Sanchez, L., Sparrow, K., and Carney, A.S., An evaluation of the benefits of swimming pools for the hearing and ear health status of young indigenous Australians: a whole of population study across multiple remote indigenous communities. 2009 -2011. Contribution to a roundtable on methodologies in Aboriginal research, Audiology Society of Australia National Conference, Sydney, 16-19 May, 2010.

Sanchez, L., Turner, D., Sparrow, K., Buxton, S., Kapadia, S., Flint, S., Eckert, B., Howard, A., Iskov, Q., Loades, N., and Loades, C., Prevalence of ear health and hearing problems in remote and urban Indigenous school-age children, oral poster, Audiology Society of Australia National Conference, Sydney, 16-19 May, 2010.

Sanchez, L., Sparrow, K. and Carney, A.S., The Swimming Pools Project: ear health and hearing in Indigenous children in remote SA , invited presentation to the Aboriginal Health Network, Nunkuwarrin Yunti, Adelaide, 22 July 2010.

Flinders Journal, July 2010, Hearing the needs of remote communities.

Sanchez, L., invited talk to the University of the Third Age (Flinders University branch), Brighton, Ear Health and Hearing in Indigenous children in remote South Australia, 10 August 2010.

Sanchez, L., Flinders University Library's Fridays at the Library public seminar series, Pina Palya: making connections between swimming pools and 'good ears' in remote Indigenous children, 12 November 2010.

The Anangu Lands Paper Tracker, Evidence-based initiatives: the impact of swimming pools, Oct. 2008, updated November 2010.

Sanchez, L., Turner, D. and Carney, A. S, Preparation of data and input to Country Health SA's application, Ear Health Proposal, 2010-2011, to the Commonwealth Govt.

Sanchez, L., Sparrow, K. Carney, A.S., Turner, D., December, 2010. Whole-of-population studies of ear health and hearing in remote and urban Indigenous school-age children in South Australia. SA Public Health Bulletin, 7 (3), pp. 27-31.

http://www.health.sa.gov.au/pehs/publications/10039.3_phb_dec2010_web.pdf

Flinders Medical Centre E – News, April 2010 article on the Swimming Pool study.

2011

McFarlane, T., Sanchez, L., An update on the impact of swimming pools on ear health and hearing in remote Aboriginal children. Seminar to the ENT Unit, The Queen Elizabeth Hospital, June 2011.

Sanchez, L., Invited presentation to the Regional Planning Day, SA Health and DECD strategy to improve the Ear Health and Hearing of Aboriginal children living in Western metro Adelaide. 11 April 2011.

Sanchez, L., Sparrow, K., Carney, A.S. and Turner, D., Do swimming pools in remote Indigenous communities benefit the hearing and ear health status of young indigenous Australians? A whole of population study across multiple remote indigenous communities. 2009 -2011. Australian Society for Medical Research, 50th National Scientific Conference, Indigenous Health: Action on Prevention, Cairns, 13-16 November, 2011.

Sanchez, L., Invited presentations to DECS Hearing Impairment Coordinators Annual In-Service meeting, 26/8/2011: update on the Indigenous research work and on conductive hearing loss.

Sanchez, L., Continuing input to reference committee on the joint SA Health and DECD development of the Early Years Hearing program, Western Region of Adelaide.

Sanchez, L., Carney, A. S. and Turner, D., Preparation of data and consultation with Country Health SA Local Health Network for the Indigenous Healthy Ears project, 2011-2013.

2012

Linnett Sanchez, Karen Sparrow, David Turner, Simon Carney, Sandra Buxton, Ailsa Howard, Rob Johnston, Greg Pedder, Whole of population studies of ear health and hearing in remote and urban Indigenous and non-indigenous school-age children in South Australia. Oral presentation at ASOHNS Aboriginal Ear Disease Multi-disciplinary Study Day, 31 March, 2012, Adelaide.

Linnett Sanchez, David Turner, Karen Sparrow, Trish McFarlane, Simon Carney. Do tissue spears used to clear ear canal pus improve the hearing of Indigenous Australian children with chronic suppurative otitis media? Oral presentation at ASOHNS Aboriginal Ear Disease Multi-disciplinary Study Day, 31 March, 2012, Adelaide.

Linnett Sanchez, David Turner, Karen Sparrow, Trish McFarlane, Simon Carney. Do tissue spears used to clear ear canal pus improve the hearing of Indigenous Australian children with chronic suppurative otitis media? Oral presentation at 21st World Congress of Audiology, April 29-May 3, 2012, Moscow, Russia.

Linnett Sanchez, David Turner, Karen Sparrow, Trish McFarlane, Simon Carney. Do tissue spears used to clear ear canal pus improve the hearing of Indigenous Australian children with chronic suppurative otitis media? Oral presentation at Audiology Australia National Conference 2012, 1-4 July, Adelaide.

Linnett Sanchez, David Turner, Karen Sparrow, Trish McFarlane, Simon Carney. Do swimming pools in remote Indigenous communities benefit the hearing and ear health status of young indigenous Australians? Oral presentation at Audiology Australia National Conference 2012, 1-4 July, Adelaide.

Appendix 2: Medical Diagnostic Pro-forma

Flinders University Department of Speech Pathology and Audiology Swimming Pools Research Project: Medical Otoscopy: APY T1/10



Background Information		
Family name:		Given name(s):
Sex: Male <input type="checkbox"/>	Female <input type="checkbox"/>	Age/dob: School grade:
Date seen:		Locality:
Indigenous <input type="checkbox"/>	Non-indigenous <input type="checkbox"/>	Video-otoscope operator:
		Video file no: Right Ear Video File no: Left Ear

SECTION A External Ear:

Right Ear

Left Ear

1 = Normal

2 = Complete wax obstruction

3 = Limited view

4 = Pus

5 = Other (- comment) _____

SECTION B Tympanic Membrane/middle ear:

1 = Normal

2 = Healed Chronic Otitis Media

(intact drum with tympanosclerosis / scar or healed perforation – NO retraction or perforation)

3 = Inactive Mucosal Chronic Otitis Media

(dry perforation with normal middle ear mucosa)

3a = <25%

3b = 25-50%

3c = >50%

	Right Ear	Left Ear
4 = Inactive Squamous Chronic Otitis Media (intact tympanic membrane with retraction pocket with no keratin)	<input type="checkbox"/>	<input type="checkbox"/>
5 = Active Mucosal Chronic Otitis Media (wet perforation with middle ear mucosal inflammation – no keratin)	<input type="checkbox"/>	<input type="checkbox"/>
5a = <25%	<input type="checkbox"/>	<input type="checkbox"/>
5b = 25-50%	<input type="checkbox"/>	<input type="checkbox"/>
5c = >50%	<input type="checkbox"/>	<input type="checkbox"/>
6 = Active Squamous Chronic Otitis Media (cholesteatoma – keratin in middle ear or retraction pocket)	<input type="checkbox"/>	<input type="checkbox"/>
7 = fluid (OME) (Intact tympanic membrane)	<input type="checkbox"/>	<input type="checkbox"/>
8 = pus (AOM) (Intact tympanic membrane)	<input type="checkbox"/>	<input type="checkbox"/>

Clinical/management recommendation(s):

Doctor's name: _____

Date: _____

Appendix 3: Project Equipment

Audiometers:

- 2 x Amplivox 160 Screening audiometer
- 1 x Amplivox 170 Screening audiometer
- 2 x Amplivox 240 Diagnostic audiometer (with bone conduction facility)
- 1 x GSI 66 audiometer

Tympanometers:

- 1 x GSI 38 Autotymp
- 1 x GSI 39 Autotymp
- 1 x Madsen Otoflex 100

Otoscopes:

- 10 x WelchAllyn rechargeable fibreoptic otoscopes

Video Otoscopes:

- 2 x WelchAllyn Digital MacroView otoscope

Computers:

- 2 x Lenovo Think Pad laptops

Otoacoustic Emissions instrument:

- 1 x Otodynamics Otoport Advance

Scanner:

- 1 x Fujitsu fi-6130

Appendix 4: Comparisons between 3 Swimming Pool Studies in remote Indigenous Australian communities in which ear health was assessed

Flinders University/DHA, (2012). An evaluation of the benefits of swimming pools for the hearing and ear health of young Indigenous Australians.

HPE/DHA, (2010). Evaluation of the sustainability and benefits of swimming pools in the APY Lands in South Australia.

Lehmann, D. et al. (2003). Benefits of swimming pools in two remote Aboriginal communities in Western Australia: intervention study, *BMJ* 327: 415-419.

Study feature	Lehmann et al.,(2003)	HPE/DoHA (2010)	Flinders University (2012)	Comments
Number of communities with pools	2	3	4	
Use of control communities	No	No	Yes (6 control communities)	
Sample size	N = 162 children	N = 262 children	N = 813 children	
Age range	< 5 y, 5-11 y, 12 to 16 y	<1 year to 19 y	School attenders, 5-18 y	
Number of research visits	4 visits over 2 years	4 visits over 2 years	6 visits over 3 years	
Timing of visits specified	Yes	Yes	Yes	
Retention rate of sample across visits	28%	14%	45.8%	Percentage of children seen on more than 2 occasions
Direct 'dosage' measure of swimming pool use	No	No	No	

Table continues.....

Study feature	Lehmann et al.,(2003)	HPE/DoHA (2010)	Flinders University (2012)	Comments
Indirect 'dosage' measure of swimming pool use	No	No	Yes*	*By <u>community</u> : as Plus Pool communities (N =4) compared to Non Pool communities (N = 6) *By <u>individual child</u> : surrogate as his/her school attendance data, available by school term for duration of project (follows from "No School No Pool" policy)
Assessments: Clinical examinations Audiological tests	Otoscopic None	Otoscopic None	Otoscopic Audiometry (screening and threshold testing for screen failures); tympanometry	The FU clinical assessment protocol used current internationally recognised classifications of otitis media and middle ear disease (Scott-Brown, 2008)
Outcome measures reported	Otoscopy	Otoscopy	Otoscopy Audiometry (screening pass rate and hearing levels) Tympanometry	
Description of assessing staff	Paediatricians (with initial ENT crosschecks)	'doctors' (unspecified)	Audiologists and ENT specialists	Flinders University retained the same core research staff for all 6 visits. All additional professional staff were trained in the research protocol prior to each visit.

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Hopkins, S. and Morris, P., (2009). Rapid evidence summary - Does ear health screening improve outcomes in young children? Retrieved from:
<http://www.healthinfonet.ecu.edu.au/other-health-conditions/ear/reviews/other-reviews>

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