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The impacts of higher turnover and higher use of short-term staff on the cost-effectiveness of remote Australian primary care services

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Abstract

Objectives:

To compare the cost-effectiveness of:

i. higher with lower turnover of resident nurses and Aboriginal Health Practitioners; and

ii. higher with lower use of agency-employed nurses;

and quantify associations between health care costs and staffing patterns in remote Northern Territory community primary care clinics.

Design:

Observational cohort study, using hospital admission, financial, and payroll data for the period 2013-2015

Setting:

53 Northern Territory Government (Australia) run primary care clinics in remote communities

Outcome measures:

Incremental cost-effectiveness ratios were calculated for i. higher compared with lower turnover; and ii. higher compared with lower use of agency-employed nurses. Costs comprised primary care, travel, and hospitalisation costs. Effectiveness measures were i. total hospitalisations and ii. years of life lost per 1000 person-months. Multiple regression was performed to investigate associations between overall costs and turnover rates and use of agency-employed nurses, after adjusting for key confounders.

Results:

Higher turnover was associated with significantly higher hospitalisation rates (p<.001) and higher average health costs (p=.002) than lower turnover. Lower turnover was always more cost-effective.

Average costs were significantly (p<.001) higher when higher proportions of agency-employed nurses were employed. The probability that lower use of agency-employed nurses was more cost-effective was 0.85.

Halving turnover and reducing use of a short-term workforce has the potential to save $32 million annually in the Northern Territory.

Conclusion

High turnover of health staff is costly and associated with poorer health outcomes for Aboriginal peoples living in remote communities. High reliance on agency nurses is also very likely to be cost-*ineffective*. Investment in a coordinated range of workforce strategies that support recruitment and retention of resident nurses and Aboriginal Health Practitioners in remote clinics is needed to stabilise the workforce and thereby significantly reduce expenditure and improve health outcomes.

Keywords

Remote health, Health workforce, Turnover, Remote area nurse, Aboriginal Health Practitioner, Fly-in fly-out, Remote health services, Health manpower, Indigenous health

Article Summary

Strengths and limitations of this study

- Data are for an entire population - remote living residents in communities serviced by Northern Territory Department of Health;
- Primary and secondary care data are linked;
- Univariate analyses (calculation of Incremental Cost-effectiveness Ratios) are complemented by multiple regression analyses which adjust for key potential confounders;
- Sensitivity analyses were undertaken to test for possible differences in costs and in effectiveness that may be related to hospital admissions for dialysis and demographic composition of communities (predominantly non-Indigenous or not);
- Effectiveness of primary care used proxy measures (hospitalisation rates; years of life lost rates) which may not necessarily best reflect effectiveness of primary care.

Introduction

There is an urgent need for high quality primary care (PC) services for disadvantaged Aboriginal and Torres Strait Islander populations (referred to as Aboriginal hereafter) in remote communities of Australia if we are to 'close the gap' in health outcome inequalities. Australian Aboriginal peoples have higher levels of risk factors for many communicable and non-communicable diseases and experience higher rates of complex acute and chronic diseases such as infectious diseases, ischaemic heart disease, diabetes and chronic kidney disease compared to non-Aboriginal Australians.(1-4) Recent research shows that higher utilisation of PC services by Aboriginal people with chronic diseases is cost-effective.(5, 6) Access to, and utilisation of, effective PC, however, may be compromised in remote Northern Territory (NT)

communities by extremely high turnover rates of resident clinical staff and heavy reliance on short-term agency nurses.(7-9) Primary care costs per person rise as geographical remoteness of communities increases and population size decreases.(10-12) A large proportion of these costs relates to higher staffing costs, and costs associated with staff and patients traveling long distances.(10, 13) Workforce shortages and extremely high staff turnover (averaging 148% per annum for nurses) result in 42% of NT remote area nurses being employed on relatively expensive casual or agency contracts.(7, 10, 12, 14)

There is a lack of published quantitative evidence, however, of the costs, effectiveness, and cost-effectiveness of different staffing patterns.(15) The aims of this research, therefore, are threefold: first, to compare the cost-effectiveness of higher turnover of resident remote area nurses or midwives (nurses) and Aboriginal Health Practitioners (AHPs) with lower turnover; second, to compare the cost-effectiveness of proportionally higher use of agency-employed nurses with lower use of agency-employed nurses; and, third, to quantify the effects of nurse and AHP turnover and use of agency-employed nurses on health care costs, after adjusting for known confounders.

Methods

Study setting

The study sites were 53 NT Department of Health (DOH) remote health clinics in 46 predominantly Aboriginal communities and 7 non-Indigenous towns where resident nurses, AHPs, and Aboriginal community workers provide most clinical PC services.(7) Temporary and ongoing nursing and AHP vacancies were filled by DOH employed casual nurses, DOH employed agency nurses or, as the least preferred, most expensive alternative, by agency-employed nurses (nurses paid directly by nurse employment agencies). In this study the

proportion of agency-employed nurses was used as a marker of overall use of short-term nurses.

Patient involvement

This study comprised analysis of NT DOH secondary data and patients were not involved.

Data

Four NT DOH datasets were used: the Primary Care Information Systems (PCIS), Hospital Inpatients Activity (HIA), Government Accounting System (GAS) and Personnel Information and Payroll Systems (PIPS). The study period was 2013-2015, as this was the most recent period for which the required costs, effectiveness and workforce turnover data were available.(7)

PIPS data were used to calculate monthly turnover rates of nurses and AHPs in each month in each clinic:

$$\text{Turnover rate} = \frac{number\ of\ exits}{average\ number\ employed} \text{x}100$$

An exit was defined when a staff member ceased working at a specific remote clinic for a period of at least 12 weeks. A cut-off of 10% differentiated higher (≥10%) from lower (<10%) turnover, equating to 120% annual turnover. Previous research showed that the average annual turnover rate of nurses and AHPs in these remote NT clinics is 128%.(16)

GAS data were used to calculate PC costs in Australian dollars per month for each remote clinic. PC clinic costs comprised operational and personnel expenditures and excluded capital expenses.(12) Agency-employed nurse labour expenses were used to derive estimates of aggregated full-time equivalent (FTE) agency-employed nurses working in remote clinics each month using a standard NT DOH formula:

$$\text{Agency-employed nurse FTE} = \frac{Agency-employed\ nurse\ labour\ expenses}{2 \times average\ DOH-employed\ nurse\ cost} \quad (17)$$

Percentage use of agency-employed nurses at each clinic each month was calculated:

$$\text{Percentage of agency-employed nurses}=\frac{Agency-employed\ nurse\ FTE}{Total\ FTE\ nurse\ positions}\times 100$$

A cut-off of 10% differentiated higher (≥10%) from lower (<10%) use of agency-employed nurses. Previous research showed that FTE agency-employed nurses filled, on average, 13% of nurse positions.(7)

PCIS data were used to determine the number of PC consultations in each clinic each month. Population catchments (service populations) for each remote clinic were defined as the number of unique patients recorded in PCIS in the previous 12 months.

HIA data were used to determine the community in which each patient lived at the time of hospital admission, to calculate the number of hospitalisations for each clinic each month, and to estimate hospitalisation costs using information on diagnoses (Australian Refined Diagnosis-Related Group (DRG) codes) provided in discharge summaries: (18)

$$\text{Hospitalisation costs} = DRG\ cost\ weight \times NT\ benchmark\ prices\ .$$

Both HIA and PCIS data were used to determine age at death, from which Years of Life Lost (YLLs) were calculated using an age specific life expectancy table used in the Australian Burden of Disease study.(2)

Both GAS and PCIS data were used to estimate PC costs each month in each clinic, calculated by first deriving an average consultation cost which was the overall estimated expenditure of the clinic each year divided by the total occasions of service in that year. PC costs per person per month were calculated as the average consultation cost multiplied by the number of consultations per person-month. Travel costs were calculated by doubling the straight line distance between the resident community and nearest hospital, based on a flat rate of $2 per kilometre.(19)

Analyses

Two separate cost-effectiveness analyses were undertaken. In the first analysis (denoted in equations by subscript 1) comparison of costs and effects were according to whether clinic-months had higher or lower turnover rates, whereas in the second analysis comparisons were by whether clinic-months had higher or lower use of agency-employed nurses.

Effects for the respective analyses were calculated as follows:

$$\text{Effect}_1=\frac{Total\ number\ of\ hospitalisations}{Total\ number\ of\ person-months}\text{x}1000\ ;$$

$$\text{Effect}_2=\frac{Total\ number\ of\ YLLs}{Total\ number\ of\ person-months}\ \text{x}\ 1000\ .$$

Total hospitalisation and YLLs rates were used as these measures of benefit in the evaluation were accessible and, having previously been reported in the peer-reviewed cost-effectiveness extant literature in the remote Australian context, were known to be acceptable proxy measures for the effectiveness of primary care.(5, 6)

Costs for the respective analyses were calculated as follows:

$$\text{Costs}_{1,2}=\frac{PC+Travel+Hospitalisation\ costs}{Total\ number\ of\ person-months}\ \text{x}\ 1000.$$

Costs and effects were measured for each person-month using current expenditure and health care data within the short study timeframe. No future costs and health outcomes were considered, nor was discounting considered necessary in this study. The incremental cost-effectiveness ratio (ICER) for the first analysis was calculated as the difference in average health costs per 1000 person-months divided by the difference in effects (hospitalisation rates) per 1000 person-months:

$$\text{ICER}_1=\frac{Costs\ in\ high\ turnover\ clinic\ months-Costs\ in\ lower\ turnover\ clinic\ months}{Effects\ in\ high\ turnover\ clinic\ months-Effects\ in\ lower\ turnover\ clinic\ months}$$

The ICER for the second analysis was calculated as the difference in average health costs per 1000 person-months, divided by the difference in effects (YLLs) per 1000 person-months:

$$ICER_2=\frac{Costs\ in\ higher\ use\ of\ agency\ employed\ nurses\ clinic\ months - Costs\ in\ lower\ use\ of\ agency\ employed\ nurses\ clinic\ months}{Effects\ in\ higher\ use\ of\ agency\ employed\ nurses\ clinic\ months - Effects\ in\ lower\ use\ of\ agency\ employed\ nurses\ clinic\ months}$$

Overall hospitalisation rates and YLLs rates were proxies for PC effectiveness in the first and second analyses, respectively. In both analyses the perspective of the NT Government was used to identify relevant costs incurred, which included PC, travel, and hospitalisation costs per 1000 person-months. A 'top down' approach was used to allocate total remote health expenditure to each clinic, as described elsewhere.(12) All costs were based on actual expenditure.

In addition to calculating ICER point estimates, 2000 Bootstrap replicates were used to plot cost-effectiveness planes (mean differences in the cost and effect pairs) and to construct cost-effectiveness acceptability curves (probability that lower turnover or lower proportional use of agency-employed nurses is cost-effective) to investigate uncertainty. Calculations of ICER also included two sensitivity analyses, to examine costs and effects if:

(1) clinics servicing predominantly non-Aboriginal communities were excluded; and

(2) hospitalisations for renal dialysis were excluded.

The average NT cost per hospitalisation of $4,213 was used as the benchmark price for a hospitalisation.(18) A threshold of $120,000 was used as the benchmark price for a YLL.(20)

Multiple regression was used to investigate associations between overall costs and nurse and AHP turnover rates and proportional use of agency-employed nurses, after adjusting for key confounders. Potential confounders included Euclidean distance to the nearest hospital, PC consultation rates, and hospitalisation rates (both total and potentially preventable).

StataSE v14 was used for all analyses. A .05 level of statistical significance was used.

Ethics

Ethics approval was received from the Human Research Ethics Committee of the NT DOH and Menzies School of Health Research (2015-2363).

Results

Between 2013 and 2015 there were 1,266,708 person-months, 46,276 hospital admissions, 2,058,829 PC consultations, and a service population of approximately 35,000 persons. Total health costs were $603 million and there were 530 deaths with an estimated 17,750 YLLs.

1. Higher versus lower turnover

Remote clinic-months with lower staff turnover have both significantly lower hospitalisation rates (p<.001) and lower average health cost rates (p=.002) than higher staff turnover clinic-months. (Table 1) Sensitivity analyses confirmed these results.

Lower turnover was always associated with reduced hospitalisation rates and, in almost all instances, with savings in average health care costs compared to higher turnover. (Figure 1) PC was cost-effective with ICER being $1,708 per hospitalisation (savings in both numerator and denominator). At the current NT threshold of $4,213 per hospitalisation, the probability of lower turnover being more cost-effective is 1. (Figure 2)

Table 1. Average health costs, hospitalisations, and incremental cost-effectiveness ratio for higher and lower staff turnover months, 2013-15

		Total	Sensitivity analysis 1: Excluding predominantly non-Aboriginal communities	Sensitivity analysis 2: Excluding hospitalisations for renal dialysis
n (person-months)	High monthly turnover (≥10%)	229,968	193,328	229,968
	Low monthly turnover (<10%)	1,036,740	878,406	1,036,740
Hospitalisations (per 1000 person-months)	High monthly turnover (≥10%)	45.3	51.7	17.8
	Low monthly turnover (<10%)	34.6	38.4	16.0
	p-value	<.001	<.001	<.001
Average health cost ($) (per 1000 person-months)	High monthly turnover (≥10%)	$491,043	$531,865	$446,344
	Low monthly turnover (<10%)	$472,826	$511,977	$440,355
	p-value	.002	.003	.271
Incremental cost-effectiveness ratio		$1,708	$1,500	$3,365

2. Higher versus lower proportional use of agency-employed staff

Remote clinic-months with higher proportional use of agency-employed nurses have both a significantly higher average health cost rate (p<.001) and higher YLLs rate (p<.001) than clinic-months with lower use. (Table 2) Both sensitivity analyses confirmed decreased effectiveness of higher proportional use of agency-employed nurses. In remote Aboriginal communities, however, only overall costs were higher in clinic-months that had proportionally lower use of agency-employed nurses.

Lower proportional use of agency nurses was always associated with health cost savings though less strongly associated with fewer YLLs. (Figure 3) At the threshold value of $120,000 per YLL, the probability of lower use of agency-employed nurses being more cost-effective was 0.849. (Figure 4)

Table 2. Average health costs, years of life lost, and incremental cost-effectiveness ratio for higher and lower proportional use of agency-employed nurses, 2013-15

		Total	Sensitivity analysis 1: Excluding predominantly non-Aboriginal communities	Sensitivity analysis 2: Excluding hospitalisations for renal dialysis
n (person-months)	High agency nurse proportion (≥10%)	813,284	727,488	813,284
	Low agency nurse proportion (<10%)	453,424	344,246	453,424
YLL (per 1000 person-months)	High agency nurse proportion (≥10%)	14.4	13.5	14.4
	Low agency nurse proportion (<10%)	13.3	12.9	13.3
	p-value	<.001	.005	<.001
Average health cost ($) (per 1000 person-months)	High agency nurse proportion (≥10%)	$486,195	$512,609	$451,422
	Low agency nurse proportion (<10%)	$458,086	$521,809	$423,543
	p-value	<.001	<.001	<.001
ICER		$23,847	-$13,837	$23,652

3. Multiple regression modelling of overall cost rates

Overall health cost rates are significantly associated with hospitalisations, potentially preventable hospitalisations, PC consultations, turnover, use of agency-employed nurses, and distance to nearest hospital. (Table 3) Each 10% increase in annual turnover is associated with an increased cost of $11 per person-month. For each 10% increase in proportion of agency-employed nurses used, there is an associated increase in cost of $10 per person-month. One preventable hospitalisation is associated with an increased cost of $10,063, which is in addition to the costs of a normal hospitalisation. Sensitivity analyses (not shown) revealed similar coefficient estimates.

Assuming a service population of 35,000 residents, reducing turnover from 120% per annum to 60% and no longer using agency-employed nurses (reducing from 13% to 0%) results in potential savings of $32 million annually in PC, hospitalisations, and travel costs.

Table 3. Multiple linear regression model predicting total health costs per person-month

	Coefficient	95% CI Lower limit	95% CI Upper limit
Number of hospitalisations	2591**	2584	2598
10% increase in nurse and AHP annual turnover	11**	7	15
10% increase in proportional use of agency nurses	10**	8	11
Potentially preventable hospitalisations	10063**	10001	10126
Euclidian distance to hospital (km)	0.16**	0.14	0.17
Number of Primary Care consultations	170**	169	171

** p<.001; AHP Aboriginal Health Practitioners; CI Confidence interval.

Discussion

This landmark empirical study shows that lower nurse and AHP turnover is associated with significantly lower hospitalisations (p<.001), lower average health cost rates (p=.002), and is consistently more cost-effective than higher turnover. The potential savings in health care costs of reducing staff turnover are in the order of $32 million annually. Also, lower use of short-term agency nurses has an 85% likelihood of being more cost-effective than higher use. These important findings for policymakers and health service managers suggest that effective investments in workforce strategies that reduce turnover rates and decrease reliance on short-term agency nurses may have very significant net benefits, both to the health services' budgets as well as to longer term health outcomes for disadvantaged Aboriginal populations.

This research highlights a pressing need to invest in the systematic implementation of a co-ordinated range of short and longer term remote workforce strategies in order to stabilise the workforce, improve continuity of care, and thereby improve health outcomes. Whilst our

knowledge about the effectiveness of various PC workforce retention interventions is incomplete (21), available evidence suggests that effective short-term retention strategies include:

- Ensuring necessary infrastructure, including adequate housing, vehicle, and communication technologies;
- Offering realistic remuneration, including salary packaging and retention bonuses;
- Ensuring organisational effectiveness by (i) strengthening health service and clinic management and leadership, (ii) ensuring comprehensive staff orientation and induction, and (iii) maintaining a professional environment through mentoring, ongoing professional development, and promoting scholarship;
- Providing appropriate personal and family support for employees; and
- Implementing alternative workforce models that are more likely to ensure continuity of care, such as employing nurses to work one month on, one month off in shared positions.

Longer-term retention strategies may include:

- Providing sufficient funding (22, 23) to ensure an adequate supply of remote health professionals relative to population needs without undue reliance on short-term staff;
- Increased recruitment of, and support for, Aboriginal people into clinical and non-clinical roles. Training models which enable training of AHPs to be largely based in remote communities may be effective;
- Based on lessons learnt from the integrated rural medical training pathway, building appropriate training pathways for remote area nurses in partnership with local educational institutions, with a particular focus on appropriate student selection, a contextualised program, and a supported post-graduate employment pathway. This is likely to result in a better prepared and more stable nursing workforce;

- Transitioning governance arrangements from NT Government-run to Aboriginal community control. While it is not known whether community-control of health services is associated with lower health workforce turnover and lower use of short-term agency nurses, we do know that Aboriginal Community Controlled Health Services (ACCHSs) employ a high proportion of Aboriginal staff (24), and that family connections (25) and a sense of ownership of the service (26) contribute to improved access. (27, 28)

This study is not without some limitations. Estimates of the effectiveness of PC used proxy measures, which may not necessarily best reflect effectiveness of PC. Comparison groups for cost-effectiveness analyses were also somewhat arbitrarily defined and it would have been preferable to make comparisons on the basis of use of all agency nurses, not just of agency-employed nurses. However, we were not able to accurately identify DOH-employed agency nurses within the payroll data. Our cost estimates may also be imprecise, as they are dependent on the quality of administrative data on expenditure recorded in GAS and on consultation data recorded in PCIS. Our study also did not include effects of any policy measures designed to reduce staff turnover, nor did it attempt to measure the costs of introducing such policies. While the findings of our study are likely generalisable to other primary care clinics in remote, predominantly Aboriginal communities in Australia, caution is advised in generalising beyond these limits. This is an observational study comparing two different situations (higher vs lower turnover; higher vs lower proportional use of agency-employed nurses) using existing administrative data. It is indicative of two simple workforce policy scenarios in which cost-effectiveness information is otherwise lacking. No evidence synthesis and decision modelling were undertaken in this study.

Despite its limitations, the findings of this research provide critically important evidence for policymakers seeking to improve health outcomes for Aboriginal people living in remote Australia while responsibly managing finite health budgets. There is great potential for more

cost-effective PC to be attained. This will require PC workforce turnover, retention, and use of short-term staff to be addressed as a priority.

Conclusion

Higher resident nurse and AHP turnover is costly and associated with poorer health outcomes for Aboriginal people. Halving the current annual turnover to 60% and reducing use of agency-employed nurses has the potential to reduce costs to the NT health system by $32 million each year. Systemic investment in a range of co-ordinated workforce strategies is needed to stabilise the remote workforce, save money, improve Aboriginal health outcomes and 'close the gap'.

List of Abbreviations

ACCHS	Aboriginal Community Controlled Health Service
AHPs	Aboriginal Health Practitioners
DOH	Department of Health
DRG	Diagnosis-Related Group
FTE	Full-time Equivalent
GAS	Government Accounting System
HIA	Hospital Inpatients Activity
ICER	Incremental Cost-Effectiveness Ratio
NT	Northern Territory
PC	Primary Care
PCIS	Primary Care Information Systems

PIPS	Personnel Information and Payroll Systems
YLL	Year of Life Lost

Declarations

Ethics approval

Ethics approval was received from the Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research (2015-2363).

Original protocol for the study

The original protocol for the study is published and available (open access):

Wakerman J, Humphreys JS, Bourke L, Dunbar T, Jones M, Carey T, et al. Assessing the impact and cost of short-term health workforce in remote Indigenous communities in Australia: a mixed methods study protocol. JMIR research protocols. 2016;5(4):e135.

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Competing interests

The authors declare that they have no competing interests.

Data sharing statement

The datasets generated and analysed during the current study are not publicly available due to identifiability of remote primary care providers and the need to protect their privacy.

Author contributions

This research was conceived by JW, JH, SG, YZ and MJ. YZ led the analysis. All authors contributed to the planning and coordination of the study, interpretation of the data and drafting of the manuscript. All authors read and approved the final manuscript.

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Figure Titles

Figure 1. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%) monthly turnover rates in remote clinics

Figure 2. Cost-effectiveness acceptability curve for comparing cost-effectiveness in terms of saving hospitalisation costs between higher (≥10%) and lower (<10%) monthly nurse and Aboriginal Health Practitioner turnover rates in remote clinics

Figure 3. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%) proportional use of agency-employed nurses in remote clinics

Figure 4. Acceptability curve for comparing cost-effectiveness in terms of saving life-years between higher (≥10%) and lower (<10%) proportional use of agency nurses in remote clinics

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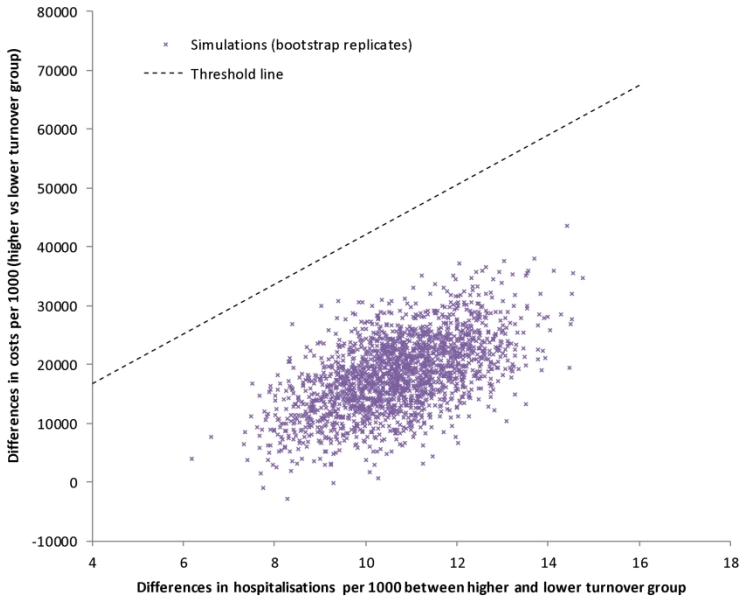

Figure 1. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%) monthly turnover rates in remote clinics

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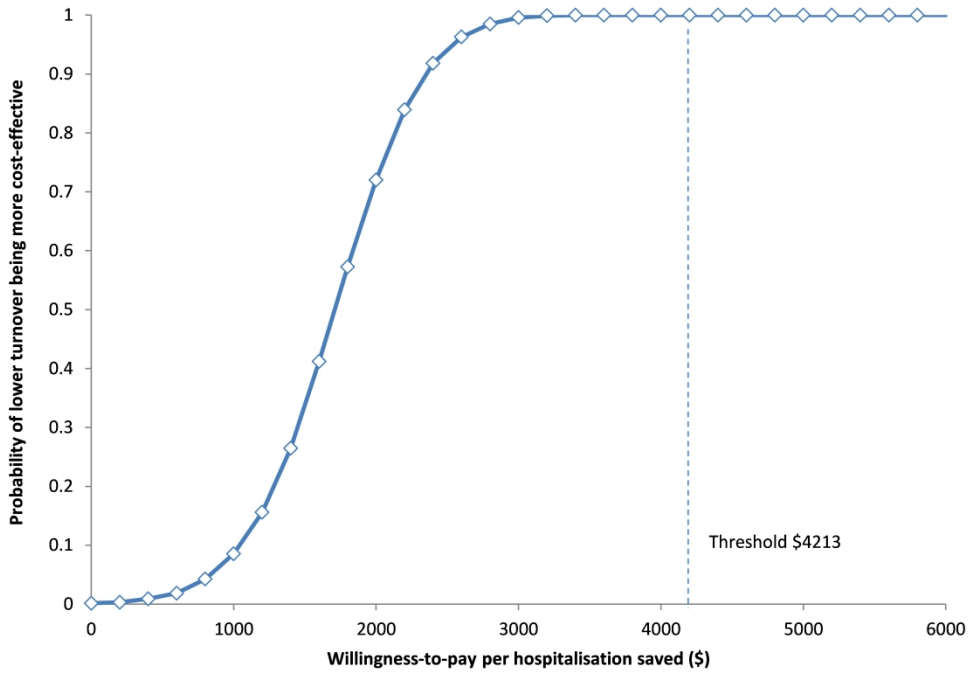

Figure 2. Cost-effectiveness acceptability curve for comparing cost-effectiveness in terms of saving hospitalisation costs between higher (≥10%) and lower (<10%) monthly nurse and Aboriginal Health Practitioner turnover rates in remote clinics

1134x810mm (600 x 600 DPI)

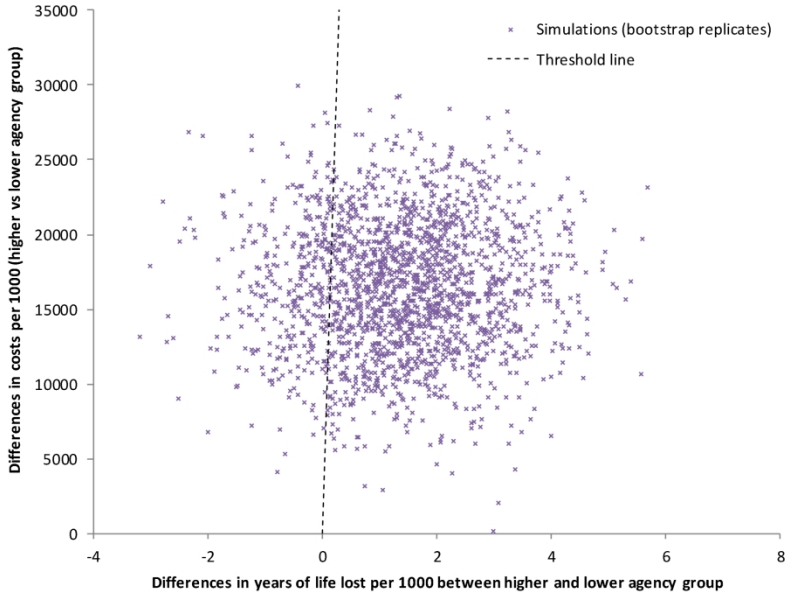

Figure 3. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%) proportional use of agency-employed nurses in remote clinics

297x209mm (300 x 300 DPI)

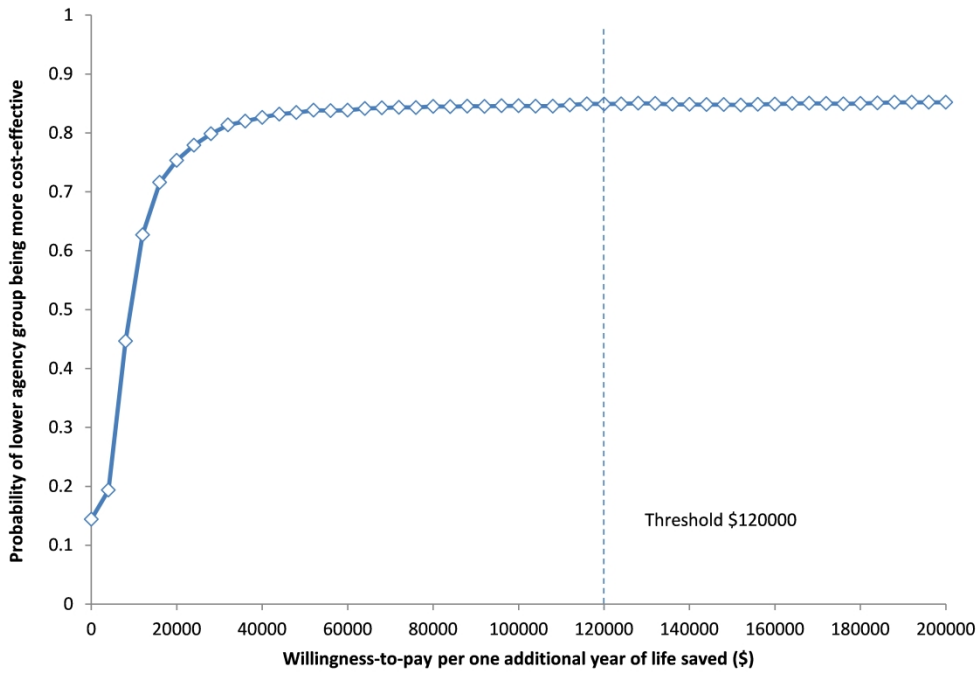

Figure 4. Acceptability curve for comparing cost-effectiveness in terms of saving life-years between higher (≥10%) and lower (<10%) proportional use of agency nurses in remote clinics

1134x810mm (600 x 600 DPI)

CHEERS checklist—Items to include when reporting economic evaluations of health interventions

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	page 1, line 1 to 2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	page 1, line 4 to page 2, line 40
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study.	page 3, line 61 to page 4, line 77
		Present the study question and its relevance for health policy or practice decisions.	page 4, line 78 to 85
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	page 4, line 87 to page 5, line 95;
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	page 4, line 87 to page 5, line 95;
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	page 8, line 165 to 167
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 5, line 108 to 110; page 6, line 119 to 121; page 7, line 141 to line 144;
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	page 5, line 102 to 103
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	page 7, line 154 to 156
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	page 7, lines 145 to 151
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	page 5, line 99 to page 8, line 183; page 3 line 47 to 58
	11b	*Synthesis-based estimates*: Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	Not applicable
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	Not applicable
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	page 5, line 99 to page 8, line 183

Section/item	Item No	Recommendation	Reported on page No/ line No
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Not applicable
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Page 5, line 102-103; page 5, line 111 to 113; page 7, line 154 to 156
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	page 14, line 293 to 294
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Not applicable
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	page 6, line 141 to page 8, line 183
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	page 8, line 170 to 173; page 8, line 177 to 178; page 9, line 188 to 190
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	page 9, line 192 to 194; page 10, Table 1; page 10, line 206 to 208; page 11, Table 2
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	Page 9, line 195 to 199; page 10, line 212 to 215; Figures 1 to 4; page 10, Table 1; page 11, Table 2.
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Not applicable
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Not applicable
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	page 12, line 238 to page 15, line 299

Section/item	Item No	Recommendation	Reported on page No/ line No
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	page 16, line 332 to page 16 line 335
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	page 16, line 336 to 337

For consistency, the CHEERS statement checklist format is based on the format of the CONSORT statement checklist

BMJ Open

Costs and effects of higher turnover of nurses and Aboriginal Health Practitioners and higher use of short-term nurses in remote Australian primary care services: An observational cohort study

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Costs and effects of higher turnover of nurses and Aboriginal Health Practitioners and higher use of short-term nurses in remote Australian primary care services: An observational cohort study

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Word count

3262

Abstract

Objectives:

To compare the costs and effects of higher turnover of resident nurses and Aboriginal Health Practitioners and higher use of agency-employed nurses in remote primary care services and quantify associations between staffing patterns and health outcomes in remote primary care clinics in the Northern Territory (NT) of Australia.

Design:

Observational cohort study, using hospital admission, financial, and payroll data for the period 2013-2015.

Setting:

53 NT Government run primary care clinics in remote communities.

Outcome measures:

Incremental cost-effectiveness ratios were calculated for higher compared with lower turnover and higher compared with lower use of agency-employed nurses. Costs comprised primary care, travel, and hospitalisation costs. Effect measures were total hospitalisations and years of life lost per 1000 person-months. Multiple regression was performed to investigate associations between overall health costs and turnover rates and use of agency-employed nurses, after adjusting for key confounders.

Results:

Higher turnover was associated with significantly higher hospitalisation rates (p<0.001) and higher average health costs (p=0.002) than lower turnover. Lower turnover was always more cost-effective. Average costs were significantly (p<0.001) higher when higher proportions of

agency-employed nurses were employed. The probability that lower use of agency-employed nurses was more cost-effective was 0.84. Halving turnover and reducing use of a short-term workforce has the potential to save $32 million annually in the NT.

Conclusion

High turnover of health staff is costly and associated with poorer health outcomes for Aboriginal peoples living in remote communities. High reliance on agency nurses is also very likely to be cost-*ineffective*. Investment in a coordinated range of workforce strategies that support recruitment and retention of resident nurses and Aboriginal Health Practitioners in remote clinics is needed to stabilise the workforce, minimise the risks for high staff turnover and overreliance on agency nurses, and thereby significantly reduce expenditure and improve health outcomes.

Keywords

Remote health, Health workforce, Turnover, Remote area nurse, Aboriginal Health Practitioner, Fly-in fly-out, Remote health services, Health manpower, Indigenous health

Article Summary

Strengths and limitations of this study

- Data are for an entire population - remote living residents in communities serviced by Northern Territory Department of Health;
- Primary care and secondary care data are linked;
- Univariate analyses (calculation of Incremental Cost-effectiveness Ratios) are complemented by multiple regression analyses which adjust for key potential confounders;
- Analyses included assessing differences in costs and effects that were related to hospital admissions for dialysis and demographic composition of communities (predominantly non-Aboriginal or not);
- Effectiveness of primary care used proxy measures (hospitalisation rates; years of life lost rates) which may not necessarily best reflect effectiveness of primary care.

Introduction

There is an urgent need for high quality primary care (PC) services for disadvantaged Aboriginal and Torres Strait Islander populations (referred to as Aboriginal hereafter) in remote communities of Australia. Australian Aboriginal peoples have higher levels of risk factors for many communicable and non-communicable diseases and experience higher rates of complex acute and chronic diseases such as infectious diseases, ischaemic heart disease, diabetes and chronic kidney disease compared to non-Aboriginal Australians.(1-4) The gaps in life expectancy at birth between Aboriginal and non-Aboriginal population in the Northern Territory (NT) of Australia in 2009-13 were 15 and 16 years in males and females respectively.(5) In 2016, 30% of the NT population was Aboriginal and 70% of Aboriginal population lived in rural

and remote areas.(6) Australian governments have committed to closing the gap in health outcomes between Aboriginal and non-Aboriginal Australians.(7)

In many remote NT communities, PC is mainly delivered by staff employed directly by the NT Government. In these remote communities 'resident' staff comprise, on average, 2 nurses or midwives (henceforth called nurses), 0.6 Aboriginal Health Practitioners (AHPs) and 2.2 other employees all of whom live in the communities on a medium to long-term basis. Agency-employed nurses provide, on average, 0.4 FTE of additional health manpower per clinic on a short-term, fly-in fly-out basis.(8) District medical officers and allied health professionals provide additional professional services to patients living in these remote communities through intermittent scheduled visits and telehealth consultations.

Recent research shows that higher utilisation of PC services by Aboriginal people with chronic diseases is cost-effective. Access to, and utilisation of, effective PC, however, may be compromised in remote NT communities by extremely high turnover rates of resident clinical staff and heavy reliance on short-term agency nurses.(8-10) Factors previously reported to be associated with nurse turnover in NT include professional, social and geographical isolation, the stressful work environment, unreasonably heavy workloads, lack of support from management and inadequacy of housing.(11) NT Government initiatives in the past decade to decrease nurse turnover have included changes to management practices to improve levels of support for nurses, providing increased training and professional development opportunities, increasing the flexibility of employment contracts and restructuring nursing classifications and increasing remuneration.(12, 13)

Primary care costs per person rise as geographical remoteness of communities increases and population size decreases.(14-16) A large proportion of these costs relates to higher staffing costs, and costs associated with staff and patients traveling long distances.(14, 17) Workforce shortages and extremely high staff turnover (averaging 148% per annum for nurses) result in

42% of NT remote area nurses being employed on relatively expensive casual or agency contracts.(8, 14, 16, 18)

There is a lack of published quantitative evidence, however, of the costs, effectiveness, and cost-effectiveness of different staffing patterns.(19) The aims of this research, therefore, are threefold: first, to compare the costs and effects of higher turnover of resident remote area nurses and AHPs with lower turnover; second, to compare the costs and effects of proportionally higher use of agency-employed nurses with lower use of agency-employed nurses; and, third, to quantify the effects of nurse and AHP turnover and use of agency-employed nurses on health care costs, after adjusting for known confounders.

Methods

Study setting

The study sites were 53 NT Department of Health (DOH) remote health clinics in 46 predominantly Aboriginal communities and 7 predominantly non-Aboriginal towns where resident nurses and AHPs provide most clinical PC services. Temporary and ongoing nursing and AHP vacancies were filled by DOH employed casual nurses, DOH employed agency nurses or, as the least preferred, most expensive alternative, by agency-employed nurses (nurses paid directly by nurse employment agencies). In this study the proportion of agency-employed nurses was used as a marker of overall use of short-term nurses.

Patient involvement

This study comprised analysis of NT DOH secondary data (including individual-level de-identified hospitalisation and primary care data). Patients were not directly involved in data provision.

Data

Four NT DOH datasets were used: the Primary Care Information Systems (PCIS), Hospital Inpatients Activity (HIA), Government Accounting System (GAS) and Personnel Information and Payroll Systems (PIPS). The study period was 2013-2015, as this was the most recent period for which the required costs, hospitalisations, ages at death, use of agency-employed nurses and workforce turnover data were available.(8)

PIPS data were used to calculate turnover rates of Department-employed nurses and AHPs in each month in each clinic (clinic-month):

$$\text{Turnover rate} = \frac{number\ of\ exits}{average\ number\ employed} \text{x} 100$$

An exit was defined when a staff member ceased working at a specific remote clinic for a period of at least 12 weeks. A cut-off of 10% differentiated higher (≥10%) from lower (<10%) turnover, equating to 120% annual turnover. Previous research showed that the average annual turnover rate of nurses and AHPs in these remote NT clinics is 128%.(20)

GAS data were used to calculate PC costs in Australian dollars for each clinic-month. PC clinic costs comprised operational and personnel expenditures and excluded capital expenses. Agency-employed nurse labour expenses were used to derive estimates of aggregated full-time equivalent (FTE) agency-employed nurse use in each clinic-month using a standard NT DOH formula:

$$\text{Agency-employed nurse FTE} = \frac{Agency-employed\ nurse\ labour\ expenses}{2 \times average\ DOH-employed\ nurse\ cost} \quad (21)$$

Percentage use of agency-employed nurses in each clinic-month was calculated:

$$\text{Percentage of agency-employed nurses} = \frac{Agency-employed\ nurse\ FTE}{Total\ FTE\ nurse\ positions} \times 100$$

A cut-off of 13% differentiated higher (≥13%) from lower (<13%) use of agency-employed nurses as previous research shows that FTE agency-employed nurses fill, on average, 13% of nurse positions.(8)

PCIS data were used to determine the number of PC consultations in each clinic-month. Population catchments (service populations) for each remote clinic were defined as the number of unique patients recorded in PCIS in the previous 12 months.

HIA data were used to determine the community in which each patient lived at the time of hospital admission, to calculate the number of hospitalisations in each clinic-month, and to estimate hospitalisation costs using information on diagnoses (Australian Refined Diagnosis-Related Group (DRG) codes) provided in discharge summaries: (22)

Hospitalisation costs = $DRG\ cost\ weight \times NT\ benchmark\ prices$.

Both HIA and PCIS data were used to determine age at death, from which Years of Life Lost (YLLs) were calculated using an age specific life expectancy table used in the Australian Burden of Disease study.(2)

Both GAS and PCIS data were used to estimate PC costs in each clinic-month, calculated by first deriving an average consultation cost which was the overall estimated expenditure of the clinic each year divided by the total occasions of service in that year. PC costs per person per month (person-month) were calculated as the average consultation cost multiplied by the number of consultations per person-month. Travel costs were calculated by doubling the straight line distance between the resident community and nearest hospital, based on a flat rate of $2 per kilometre.(23)

Analyses

Two separate incremental cost-effectiveness ratios were calculated using clinic-month data. In the first analysis (denoted in equations by subscript 1) comparison of costs and effects of higher turnover clinic-months were compared with lower turnover rates, whereas in the second analysis (subscript 2) costs and effects of clinic-months with higher use of agency-employed nurses were compared with lower use of agency-employed nurses.

Effects for the respective analyses were calculated as follows:

$$\text{Effect rate}_1=\frac{Total\ number\ of\ hospitalisations}{Total\ number\ of\ person-months}\text{x}1000\ ;$$

$$\text{Effect rate}_2=\frac{Total\ number\ of\ YLLs}{Total\ number\ of\ person-months}\ \text{x}\ 1000\ .$$

Total hospitalisation and YLLs rates were used as these measures of benefit in the evaluation were accessible and, having previously been reported in the peer-reviewed cost-effectiveness extant literature in the remote Australian context, were known to be acceptable proxy measures for the effectiveness of primary care.

Costs for the respective analyses were calculated as follows:

$$\text{Costs rate}=\frac{PC\ +Travel\ +Hospitalisation\ costs}{Total\ number\ of\ person-months}\ \text{x}\ 1000.$$

Costs and effects were measured for each person-month using current expenditure and health care data within the short study timeframe. No future costs or future health outcomes were considered, nor was discounting considered necessary in this study. The incremental cost-effectiveness ratio (ICER) for the first analysis was calculated as the difference in average health costs per 1000 person-months divided by the difference in effects (hospitalisation rates) per 1000 person-months:

$$\text{ICER}_1=\frac{Costs\ rate\ in\ high\ turnover\ clinic-months-Costs\ rates\ in\ lower\ turnover\ clinic-months}{Hospitalisation\ rate\ in\ high\ turnover\ clinic-months-Hospitalisation\ rate\ in\ lower\ turnover\ clinic-months}$$

The ICER for the second analysis was calculated as the difference in average health costs per 1000 person-months, divided by the difference in effects (YLLs) per 1000 person-months:

$$\text{ICER}_2=\frac{Costs\ in\ higher\ use\ of\ agency\ employed\ nurses\ clinic-months\ -Costs\ in\ \ lower\ use\ of\ agency\ employed\ nurses\ clinic-months}{YLLs\ rate\ in\ higher\ use\ of\ agency\ employed\ nurses\ clinicmonths\ -YLLs\ rate\ in\ lower\ use\ of\ agency\ employed\ nurses\ clinic-months}$$

Overall hospitalisation rates and YLLs rates were proxies for PC effectiveness in the first and second analyses, respectively. In both analyses the perspective of the NT Government was used to identify relevant costs incurred, which included PC, travel, and hospitalisation costs per

1000 person-months. A 'top down' approach was used to allocate total remote health expenditure to each clinic, as described elsewhere. All costs were based on actual expenditure.

In addition to calculating ICER point estimates, 2000 Bootstrap replicates were used to plot cost-effectiveness planes (mean differences in the cost and effect pairs) and to construct cost-effectiveness acceptability curves (probability that lower turnover or lower proportional use of agency-employed nurses is cost-effective) to investigate uncertainty. Calculations of ICER also examined variations in costs and effects if:

(1) clinics servicing predominantly non-Aboriginal communities were excluded;

(2) hospitalisations for renal dialysis were excluded; and

(3) only potentially preventable hospitalisations (PPH) were included.(24)

The average NT cost per hospitalisation of $4,213 was used as the benchmark price for a hospitalisation.(22) A threshold of $120,000 was used as the benchmark price for a YLL.(25)

Multiple regression was used to investigate associations between overall costs and nurse and AHP turnover rates and proportional use of agency-employed nurses, after adjusting for key confounders. Potential confounders included Euclidean distance to the nearest hospital, PC consultation rates, and hospitalisation rates (both total and PPH).

StataSE v14 was used for all analyses. A 0.05 level of statistical significance was used.

Ethics

Ethics approval was received from the Human Research Ethics Committee of the NT DOH and Menzies School of Health Research (2015-2363).

Results

Between 2013 and 2015 there were 1,266,708 person-months, 46,276 hospital admissions, 2,058,829 PC consultations, and a service population of approximately 35,000 persons. Total health costs were $603 million and there were 530 deaths with an estimated 17,750 YLLs.

1. Higher versus lower turnover

Remote clinic-months with lower staff turnover have both significantly lower total hospitalisation rates (p<0.001) and lower average health cost rates (p=0.002) than higher staff turnover clinic-months. (Table 1) Analyses for Aboriginal communities only and excluding hospitalisations for renal dialysis revealed similar results, however analyses of PPHs found lower staff turnover clinic-months were associated with increased costs (p<0.001) and no significant difference in PPHs rate (p=0.430) compared with higher turnover clinic-months.

For the analysis of total hospitalisations, the cost-effectiveness plane shows lower turnover was always associated with reduced hospitalisation rates and, in almost all instances, with savings in average health care costs compared to higher turnover. (Figure 1) PC was cost-effective with ICER being $1,708 per hospitalisation (savings in both numerator and denominator). At the current NT threshold of $4,213 per hospitalisation, the probability of lower turnover being more cost-effective is 1. (Figure 2)

Table 1. Average health costs, hospitalisations, and incremental cost-effectiveness ratio for higher and lower staff turnover, 2013-15

	Monthly turnover	Total hospitalisations	Excluding predominantly non-Aboriginal communities	Excluding hospitalisations for renal dialysis	Potentially preventable hospitalisations
n (person-months)	Higher (≥10%)	229,968	193,328	229,968	229,968
	Lower (<10%)	1,036,740	878,406	1,036,740	1,036,740
Hospitalisations	Higher (≥10%)	45.3	51.7	17.8	2.5
(per 1000 person-months)	Lower (<10%)	34.6	38.4	16.0	2.4
	p-value	<0.001	<0.001	<0.001	0.430
Average health cost ($)	Higher (≥10%)	$491,043	$531,865	$446,344	$289,741
(per 1000 person-	Lower (<10%)	$472,826	$511,977	$440,355	$300,740

months)	*p*-value	0.002	0.003	0.271	<0.001
Incremental cost-effectiveness ratio		$1,708	$1,500	$3,365	-$107.830

2. Higher versus lower proportional use of agency-employed staff

Remote clinic-months with higher proportional use of agency-employed nurses have both a significantly higher average health cost rate (p<0.001) and higher YLLs rate (p<0.001) than clinic-months with lower use. (Table 2) Analyses examining variations in effects which excluded predominantly non-Aboriginal communities and excluded renal dialysis hospitalisations confirmed poorer outcomes (greater YLLs rates) in clinic-months with higher proportional use of agency-employed nurses. In remote Aboriginal communities (excluding predominantly non-Aboriginal communities), however, overall costs were higher in clinic-months that had proportionally lower use of agency-employed nurses (p<0.001). PPHs analysis showed no significant differences in YLLs between clinic-months with higher and lower proportional use of agency-employed nurses.

For the analysis of the total study population, lower proportional use of agency nurses was always associated with health cost savings though less strongly associated with fewer YLLs. (Figure 3) At the threshold value of $120,000 per YLL, the probability of lower use of agency-employed nurses being more cost-effective was 0.838. (Figure 4)

Table 2. Average health costs, years of life lost, and incremental cost-effectiveness ratio for higher and lower proportional use of agency-employed nurses, 2013-15

	Agency nurse proportion	Total	Excluding predominantly non-Aboriginal communities	Excluding hospitalisations for renal dialysis	Potentially preventable hospitalisations
n (person-months)	Higher (≥13%)	704,240	636,525	704,240	704,240
	Lower (<13%)	562,468	435,209	562,468	562,468
YLL (per 1000 person-months)	Higher (≥13%)	14.6	13.7	14.6	0.0
	Lower (<13%)	13.3	12.8	13.3	0.1
	p-value	<0.001	<0.001	<0.001	0.978
Average health cost ($) (per 1000 person-months)	Higher (≥13%)	$480,915	$503,989	$446,289	$301,567
	Lower (<13%)	$470,145	$532,494	$435,375	$295,207

p-value	<0.001	<0.001	<0.001	<0.001
ICER	$7,964	-$29,310	$8,070	-$70,757

3. Multiple regression modelling of overall cost rates

Overall health cost rates were significantly associated with hospitalisations, PPHs, PC consultations, turnover, use of agency-employed nurses, and distance to nearest hospital. (Table 3) Each 10% increase in annual turnover was associated with an increased cost of $11 per person-month. For each 10% increase in proportion of agency-employed nurses used, there was an associated increase in cost of $10 per person-month. One PPH was associated with an increased cost of $10,063, which was in addition to the costs of a normal hospitalisation. Sensitivity analyses (not shown) revealed similar coefficient estimates.

Assuming a service population of 35,000 residents, reducing turnover from 120% per annum to 60% and no longer using agency-employed nurses (reducing from 13% to 0%) results in potential savings of $32 million annually in PC, hospitalisations, and travel costs.

Table 3. Multiple linear regression model predicting total health costs per person-month

	Coefficient	95% CI Lower limit	95% CI Upper limit
Number of hospitalisations	2591**	2584	2598
10% increase in nurse and AHP annual turnover	11**	7	15
10% increase in proportional use of agency nurses	10**	8	11
Potentially preventable hospitalisations	10063**	10001	10126
Euclidian distance to hospital (km)	0.16**	0.14	0.17
Number of Primary Care consultations	170**	169	171

** *p*<0.001; AHP Aboriginal Health Practitioners; CI Confidence interval.

Discussion

This landmark empirical study shows that lower nurse and AHP turnover is associated with significantly lower total hospitalisations (p<0.001), lower average health cost rates (p=0.002) and is more cost-effective than higher turnover. The potential savings in health care costs of reducing staff turnover are in the order of $32 million annually. Also, lower use of short-term agency nurses has an 84% likelihood of being more cost-effective than higher use.

For Aboriginal communities, PC cost rates were significantly higher in clinic-months that had lower use of agency-employed nurses. This finding was, at face value, counter-intuitive, as agency-employed labour hire is the most expensive staffing option. One possible explanation is confounding of the association by geographical remoteness: the multiple linear regression analysis confirmed that more geographically remote clinics have higher operating costs, consistent with previous research.(14) More geographically remote clinics may also be more likely to have lower use of agency nurses and incur even higher costs, for example because agency-employed nurses may be less willing to work in the most geographically remote health services. This research used regression analysis to confirm that health care costs in remote PC clinics are positively and significantly associated with hospitalisations (total and PPH), nurse and AHP turnover rates, use of agency-employed nurses, geographical remoteness and the number of primary care consultations (Table 3).

These are important findings for policymakers and health service managers. The findings suggest that effective investments in workforce strategies that reduce turnover rates and decrease undue reliance on short-term agency nurses may have very significant net benefits, both to the health services' budgets as well as to longer term health outcomes for disadvantaged Aboriginal populations.

This research highlights a pressing need to invest in the systematic implementation of a co-ordinated range of short and longer term remote workforce strategies in order to stabilise the workforce, improve continuity of care, and thereby improve health outcomes. Whilst our knowledge about the effectiveness of various PC workforce retention interventions is incomplete (26), available evidence suggests that effective short-term retention strategies should be multifaceted and include the following components: necessary infrastructure, including adequate housing, vehicle, and communication technologies; offer realistic remuneration, including salary packaging and retention bonuses; ensure organisational effectiveness by (i) strengthening health service and clinic management and leadership, (ii) ensuring comprehensive staff orientation and induction, and (iii) maintaining a professional environment through mentoring, ongoing professional development, and promoting scholarship; provide appropriate personal and family support for employees; and implement alternative workforce models that are more likely to ensure continuity of care, such as employing nurses to work one month on, one month off in shared positions.

Longer-term retention strategies, similarly, may best be bundled together, and may include: providing sufficient funding to ensure an adequate supply of remote health professionals relative to population needs without undue reliance on short-term staff; increased recruitment of, and support for, Aboriginal people to take up clinical and non-clinical roles, which may include the adoption of training models which enable AHP training to be largely based in remote communities; building appropriate training pathways for remote area nurses in partnership with local educational institutions, with a particular focus on appropriate student selection, a contextualised program, and a supported post-graduate employment pathway; and transitioning governance arrangements from NT Government-run to Aboriginal community control. While it is not known whether community-control of health services is associated with lower health workforce turnover and lower use of short-term agency nurses, we do know that Aboriginal

Community Controlled Health Services employ a high proportion of Aboriginal staff, and that family connections and a sense of ownership of the service (27) contribute to improved access. (28, 29)

This study is not without some limitations. Firstly, estimates of the effects of PC used proxy measures – total hospitalisations and YLL – which may not necessarily best reflect effectiveness of PC. While our analyses extended to investigate variability in results if only PPHs were included, these too have limitations in the context of this study. PPHs comprise <8% of total hospitalisations and the communities in this study were mostly small, so monthly PPHs rates in each remote community have the limitation of increased statistical instability, which may explain the unexpected association between higher proportional use of agency-employed nurses and lower costs. Secondly, comparison groups for costs and effects were somewhat arbitrarily defined based on clinic-month rather than individual level data. It would have been preferable to make comparisons on the basis of use of all agency nurses, not just of agency-employed nurses. However, we were not able to accurately identify DOH-employed agency nurses within the payroll data. Also, there were a small number of non-Aboriginal residents in remote Aboriginal communities. Because the non-Aboriginal residents were predominantly healthy workers, the impacts of non-Aboriginal residents on clinic-month health measures were expected to be minimal. Thirdly, our cost estimates may also be imprecise, as they are dependent on the quality of administrative data on expenditure recorded in GAS and on consultation data recorded in PCIS. Fourthly, our study also did not include effects of any policy measures designed to reduce staff turnover, nor did it attempt to measure the costs of introducing such policies. While the findings of our study are likely generalisable to other primary care clinics in remote, predominantly Aboriginal communities in Australia, caution is advised in generalising beyond these limits. This is an observational study comparing two different situations (higher vs lower turnover; higher vs lower proportional use of agency-

employed nurses) using existing administrative data. It is indicative of two simple workforce policy scenarios in which cost-effectiveness information is otherwise lacking. No evidence synthesis and decision modelling were undertaken in this study.

Despite its limitations, the findings of this research provide critically important evidence for policymakers seeking to improve health outcomes for Aboriginal people living in remote Australia while responsibly managing finite health budgets. There is great potential for more cost-effective PC to be attained. This will require PC workforce turnover, retention, and use of short-term agency-employed nurses to be addressed as a priority.

Conclusion

Higher turnover of government-employed nurses and AHPs is costly and associated with poorer health outcomes for Aboriginal people. Halving the current annual turnover rate to 60% and reducing use of agency-employed nurses has the potential to reduce costs to the NT health system by $32 million each year. Systemic investment in a range of co-ordinated workforce strategies is needed to stabilise the remote workforce, save money, improve Aboriginal health outcomes and 'close the gap'.

List of Abbreviations

AHPs	Aboriginal Health Practitioners
DOH	Department of Health
DRG	Diagnosis-Related Group
FTE	Full-time Equivalent
GAS	Government Accounting System

HIA	Hospital Inpatients Activity
ICER	Incremental Cost-Effectiveness Ratio
NT	Northern Territory
PC	Primary Care
PCIS	Primary Care Information Systems
PIPS	Personnel Information and Payroll Systems
PPH	Potentially Preventable Hospitalisation
YLL	Year of Life Lost

Declarations

Ethics approval

Ethics approval was received from the Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research (2015-2363).

Original protocol for the study

The original protocol for the study is published and available (open access):

Wakerman J, Humphreys JS, Bourke L, Dunbar T, Jones M, Carey T, et al. Assessing the impact and cost of short-term health workforce in remote Indigenous communities in Australia: a mixed methods study protocol. JMIR research protocols. 2016;5(4):e135.

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Competing interests

The authors declare that they have no competing interests.

Data sharing statement

The datasets generated and analysed during the current study are not publicly available due to identifiability of remote primary care providers and the need to protect their privacy.

Author contributions

YZ contributed to the design of the study and led analysis and drafting of the paper. JW conceived and contributed to design of the overarching study and assisted with drafting the paper. JSH contributed to the conceptualization and design of the study and assisted with drafting the manuscript. MPJ, SG, MR and DJR contributed to the design of the study, particularly the quantitative component, and provided comments on the manuscript. All authors read and approved the final manuscript.

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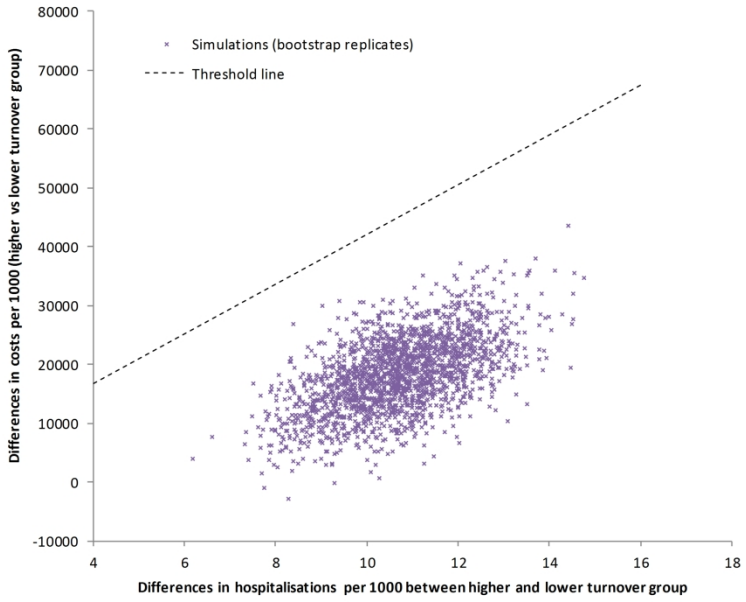
Figure Titles

Figure 1. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%) monthly turnover rates in remote clinics

Figure 2. Cost-effectiveness acceptability curve for comparing costs and effects in savings in total health costs between higher (≥10%) and lower (<10%) monthly nurse and Aboriginal Health Practitioner turnover rates in remote clinics

Figure 3. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%) proportional use of agency-employed nurses in remote clinics

Figure 4. Acceptability curve for comparing costs and effects in terms of saving life-years between higher (≥10%) and lower (<10%) proportional use of agency nurses in remote clinics



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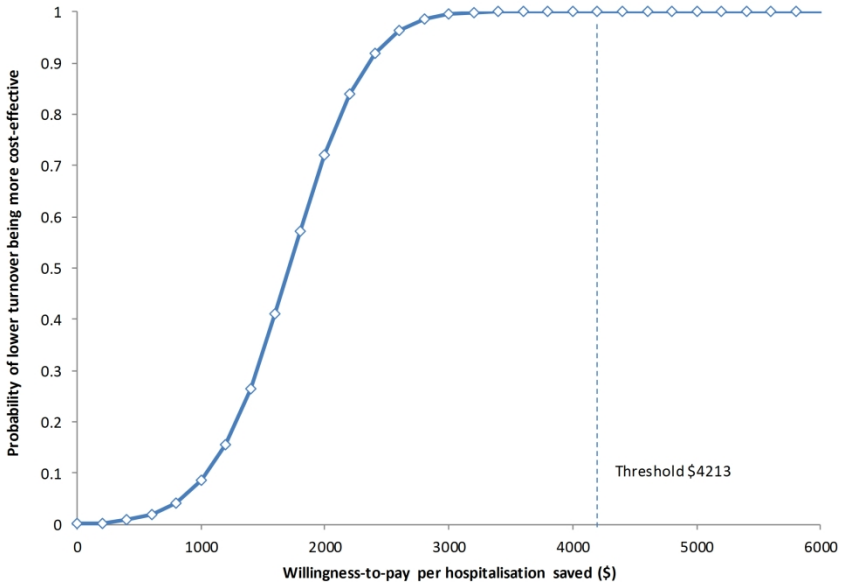

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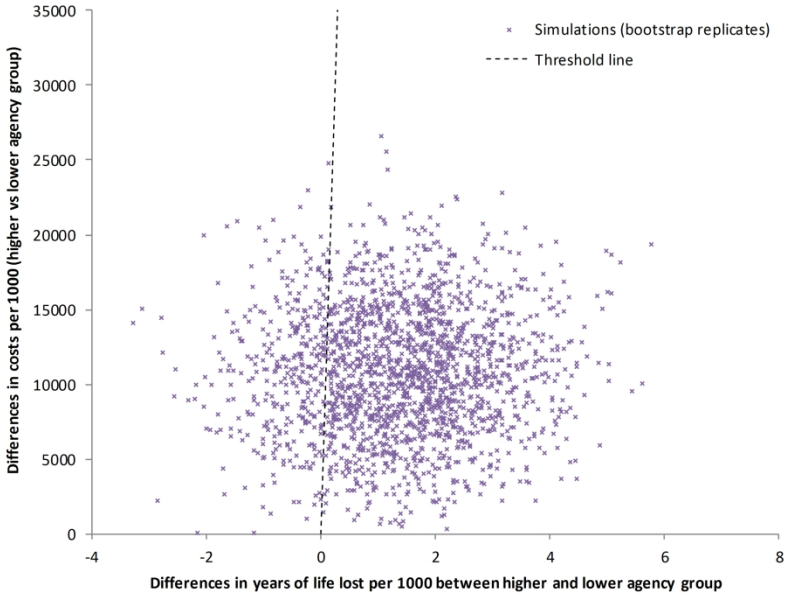

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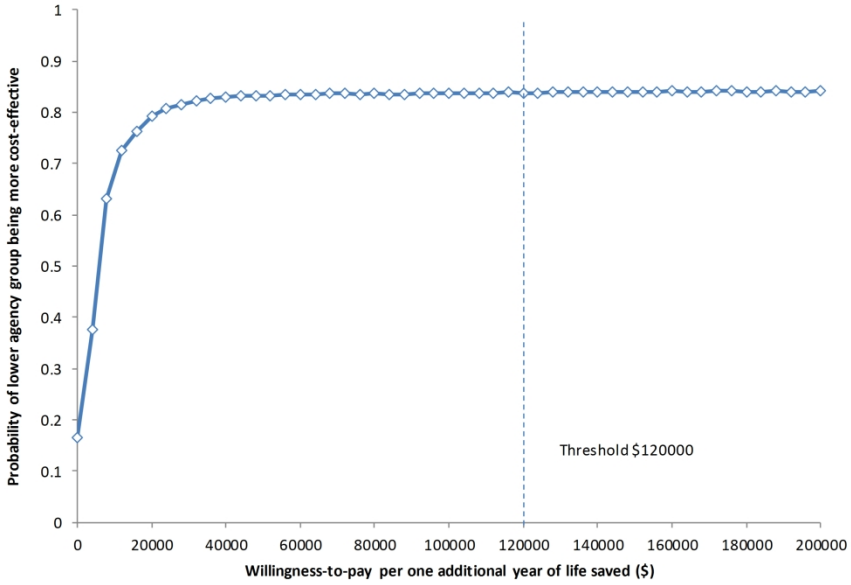

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CHEERS checklist—Items to include when reporting economic evaluations of health interventions

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	page 1, line 1 to 2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	page 1, line 4 to page 2, line 40
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study.	page 3, line 61 to page 4, line 77
		Present the study question and its relevance for health policy or practice decisions.	page 4, line 78 to 85
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	page 4, line 87 to page 5, line 95;
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	page 4, line 87 to page 5, line 95;
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	page 8, line 165 to 167
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 5, line 108 to 110; page 6, line 119 to 121; page 7, line 141 to line 144;
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	page 5, line 102 to 103
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	page 7, line 154 to 156
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	page 7, lines 145 to 151
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	page 5, line 99 to page 8, line 183; page 3 line 47 to 58
	11b	*Synthesis-based estimates*: Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	Not applicable
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	Not applicable
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	page 5, line 99 to page 8, line 183

Section/item	Item No	Recommendation	Reported on page No/ line No
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	Not applicable
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	Page 5, line 102-103; page 5, line 111 to 113; page 7, line 154 to 156
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	page 14, line 293 to 294
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	Not applicable
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	page 6, line 141 to page 8, line 183
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	page 8, line 170 to 173; page 8, line 177 to 178; page 9, line 188 to 190
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	page 9, line 192 to 194; page 10, Table 1; page 10, line 206 to 208; page 11, Table 2
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	Page 9, line 195 to 199; page 10, line 212 to 215; Figures 1 to 4; page 10, Table 1; page 11, Table 2.
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Not applicable
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	Not applicable
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	page 12, line 238 to page 15, line 299

Section/item	Item No	Recommendation	Reported on page No/ line No
Other			
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	page 16, line 332 to page 16 line 335
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	page 16, line 336 to 337

For consistency, the CHEERS statement checklist format is based on the format of the CONSORT statement checklist