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# **BMJ Open**

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

Journal:	BMJ Open
Manuscript ID	bmjopen-2018-023906
Article Type:	Research
Date Submitted by the Author:	30-Apr-2018
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Keywords:	HEALTH ECONOMICS, Health economics < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Human resource management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT
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3 4	1	The impacts of higher turnover and higher use of short-term staff on			
5 6	2	the cost-effectiveness of remote Australian primary care services			
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1 2					
2 3 4	58	Abstract			
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0 7	59				
8 9	60	Objectives:			
10 11 12	61	To compare the cost-effectiveness of:			
13 14	62	i. higher with lower turnover of resident nurses and Aboriginal Health Practitioners; and			
15 16 17	63	ii. higher with lower use of agency-employed nurses;			
18 19	64	and quantify associations between health care costs and staffing patterns in remote Northern			
20 21	65	Territory community primary care clinics.			
22 23 24	66	Design:			
25 26 27 28 29	67	Observational cohort study, using hospital admission, financial, and payroll data for the period			
	68	2013-2015			
30 31	69	Setting:			
32 33 34	70	53 Northern Territory Government (Australia) run primary care clinics in remote communities			
35 36 37	71	Outcome measures:			
37 38 39	72	Incremental cost-effectiveness ratios were calculated for i. higher compared with lower turnover;			
40 41	73	and ii. higher compared with lower use of agency-employed nurses. Costs comprised primary			
42 43	74	care, travel, and hospitalisation costs. Effectiveness measures were i. total hospitalisations and			
44 45	75	ii. years of life lost per 1000 person-months. Multiple regression was performed to investigate			
46 47	76	associations between overall costs and turnover rates and use of agency-employed nurses,			
48 49 50	77	after adjusting for key confounders.			
51 52 53 54 55	78	Results:			
56 57					
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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 

Stron	aths 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.
	4
ntro	duction
There	is an urgent need for high quality primary care (PC) services for disadvantaged Aborigina
and T	orres Strait Islander populations (referred to as Aboriginal hereafter) in remote
comm	unities of Australia if we are to 'close the gap' in health outcome inequalities. Australian
Abori	ginal peoples have higher levels of risk factors for many communicable and non-
comm	unicable diseases and experience higher rates of complex acute and chronic diseases
	as infectious diseases, ischaemic heart disease, diabetes and chronic kidney disease
such	ared to pap Abariainal Australians (1.4) Recent research shows that higher utilization of
such a	
such comp PC se	ervices by Aboriginal people with chronic diseases is cost-effective.(5, 6) Access to, and

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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.

#### 140 Methods

#### 141 Study setting

142 The study sites were 53 NT Department of Health (DOH) remote health clinics in 46
143 predominantly Aboriginal communities and 7 non-Indigenous towns where resident nurses,
144 AHPs, and Aboriginal community workers provide most clinical PC services.(7) Temporary and
145 ongoing nursing and AHP vacancies were filled by DOH employed casual nurses, DOH
146 employed agency nurses or, as the least preferred, most expensive alternative, by agency147 employed nurses (nurses paid directly by nurse employment agencies). In this study the

1 2		
2 3 4	148	proportion of agency-employed nurses was used as a marker of overall use of short-term
5 6 7	149	nurses.
8	150	Patient involvement
9 10	151	This study comprised analysis of NT DOH secondary data and patients were not involved.
11 12 12	152	
13 14 15	153	Data
16 17	154	Four NT DOH datasets were used: the Primary Care Information Systems (PCIS), Hospital
18 19	155	Inpatients Activity (HIA), Government Accounting System (GAS) and Personnel Information and
20 21	156	Payroll Systems (PIPS). The study period was 2013-2015, as this was the most recent period
22 23 24	157	for which the required costs, effectiveness and workforce turnover data were available.(7)
25 26	158	PIPS data were used to calculate monthly turnover rates of nurses and AHPs in each month in
27 28	159	each clinic:
29 30 31 32	160	Turnover rate= $\frac{number of exits}{average number employed} x100$
33 34	161	An exit was defined when a staff member ceased working at a specific remote clinic for a period
35 36	162	of at least 12 weeks. A cut-off of 10% differentiated higher (≥10%) from lower (<10%) turnover,
37 38	163	equating to 120% annual turnover. Previous research showed that the average annual turnover
39 40 41	164	rate of nurses and AHPs in these remote NT clinics is 128%.(16)
42 43	165	GAS data were used to calculate PC costs in Australian dollars per month for each remote
44 45	166	clinic. PC clinic costs comprised operational and personnel expenditures and excluded capital
46 47	167	expenses.(12) Agency-employed nurse labour expenses were used to derive estimates of
48 49	168	aggregated full-time equivalent (FTE) agency-employed nurses working in remote clinics each
50 51 52	169	month using a standard NT DOH formula:
53 54 55 56 57	170	Agency-employed nurse $FTE = \frac{Agency - employed nurse labour expenses}{2 \times average DOH - employed nurse cost}$ (17)
58		7
59 60		For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

1 2 3	171	Percentage use of agency-employed nurses at each clinic each month was calculated:			
4 5		Agency-employed nurse FTF			
6 7 8	172	Percentage of agency-employed nurses= $\frac{Igency - employed nurse positions}{Total FTE nurse positions} \times 100$			
8 9 10 11 12 13 14 15 16	173	A cut-off of 10% differentiated higher (≥10%) from lower (<10%) use of agency-employed			
	174	nurses. Previous research showed that FTE agency-employed nurses filled, on average, 13% of			
	175	nurse positions.(7)			
	176	PCIS data were used to determine the number of PC consultations in each clinic each month.			
17 18 10	177	Population catchments (service populations) for each remote clinic were defined as the number			
20 21	178	of unique patients recorded in PCIS in the previous 12 months.			
22 23	179	HIA data were used to determine the community in which each patient lived at the time of			
24 25	180	hospital admission, to calculate the number of hospitalisations for each clinic each month, and			
26 27 28	181	to estimate hospitalisation costs using information on diagnoses (Australian Refined Diagnosis-			
20 29 30 31 32 33 34 35	182	Related Group (DRG) codes) provided in discharge summaries: (18)			
	183	Hospitalisation costs = $DRG \ cost \ weight \times NT \ benchmark \ prices$ .			
	184	Both HIA and PCIS data were used to determine age at death, from which Years of Life Lost			
36 37	185	(YLLs) were calculated using an age specific life expectancy table used in the Australian Burden			
38 39	186	of Disease study.(2)			
40 41 42	187	Both GAS and PCIS data were used to estimate PC costs each month in each clinic, calculated			
42 43 44	188	by first deriving an average consultation cost which was the overall estimated expenditure of the			
45 46	189	clinic each year divided by the total occasions of service in that year. PC costs per person per			
47 48	190	month were calculated as the average consultation cost multiplied by the number of			
49 50 51 52	191	consultations per person-month. Travel costs were calculated by doubling the straight line			
	192	distance between the resident community and nearest hospital, based on a flat rate of \$2 per			
53 54 55	193	kilometre.(19)			
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1 2		
2 3 4	194	Analyses
	195	Two separate cost-effectiveness analyses were undertaken. In the first analysis (denoted in
6 7	196	equations by subscript 1) comparison of costs and effects were according to whether clinic-
8 9 10	197	months had higher or lower turnover rates, whereas in the second analysis comparisons were
10 11 12	198	by whether clinic-months had higher or lower use of agency-employed nurses.
13 14 15	199	Effects for the respective analyses were calculated as follows:
16 17 18	200	$Effect_{1} = \frac{Total \ number \ of \ hospitalisations}{Total \ number \ of \ person-months} \times 1000 ;$
19 20 21	201	$Effect_2 = \frac{Total \ number \ of \ YLLs}{Total \ number \ of \ person-months} \ x \ 1000 \ .$
22 23 24	202	Total hospitalisation and YLLs rates were used as these measures of benefit in the evaluation
25 26	203	were accessible and, having previously been reported in the peer-reviewed cost-effectiveness
27 28	204	extant literature in the remote Australian context, were known to be acceptable proxy measures
29 30	205	for the effectiveness of primary care.(5, 6)
31 32 33	206	Costs for the respective analyses were calculated as follows:
34 35 36	207	$Costs_{1,2} = \frac{PC + Travel + Hospitalisation costs}{Total number of person-months} \times 1000.$
37 38 39	208	Costs and effects were measured for each person-month using current expenditure and health
40 41	209	care data within the short study timeframe. No future costs and health outcomes were
41 42 43	210	considered, nor was discounting considered necessary in this study. The incremental cost-
43 44 45	211	effectiveness ratio (ICER) for the first analysis was calculated as the difference in average
46 47	212	health costs per 1000 person-months divided by the difference in effects (hospitalisation rates)
48 49	213	per 1000 person-months:
50 51 52	214	$ICER_{1} = \frac{Costs in high turnover clinic months-Costs in lower turnover clinic months}{Effects in high turnover clinic months-Effects in lower turnover clinic months}$
54 55 56 57		
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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:

217

ICER<sub>2</sub>=

1 2

> 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

218 Overall hospitalisation rates and YLLs rates were proxies for PC effectiveness in the first and 219 second analyses, respectively. In both analyses the perspective of the NT Government was 220 used to identify relevant costs incurred, which included PC, travel, and hospitalisation costs per 221 1000 person-months. A 'top down' approach was used to allocate total remote health 222 expenditure to each clinic, as described elsewhere.(12) All costs were based on actual 223 expenditure. 224 In addition to calculating ICER point estimates, 2000 Bootstrap replicates were used to plot 225 cost-effectiveness planes (mean differences in the cost and effect pairs) and to construct cost-226 effectiveness acceptability curves (probability that lower turnover or lower proportional use of 227 agency-employed nurses is cost-effective) to investigate uncertainty. Calculations of ICER also 228 included two sensitivity analyses, to examine costs and effects if: 229 (1) clinics servicing predominantly non-Aboriginal communities were excluded; and 230 (2) hospitalisations for renal dialysis were excluded. 231 The average NT cost per hospitalisation of \$4,213 was used as the benchmark price for a 232 hospitalisation.(18) A threshold of \$120,000 was used as the benchmark price for a YLL.(20)

233 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

235 confounders. Potential confounders included Euclidean distance to the nearest hospital, PC

236 consultation rates, and hospitalisation rates (both total and potentially preventable).

4 237 StataSE v14 was used for all analyses. A .05 level of statistical significance was used.

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2 3 4	238	Ethics				
5 6	239	Ethics approval was received from the Human Research Ethics Committee of the NT DOH and				
/ 8 0	240	Menzies School of Health Research (2015-2363).				
10 11 12 12	241	Results				
13 14 15	242	Between 2013 and 2015 there were 1,266,708 person-months, 46,276 hospital admissions,				
16 17	243	2,058,829 PC consultations, and a service population of approximately 35,000 persons. Total				
18 19	244	health costs were \$603 million and there were 530 deaths with an estimated 17,750 YLLs.				
20 21	245	1. Higher versus lower turnover				
22 23	246	Remote clinic-months with lower staff turnover have both significantly lower hospitalisation rates				
24 25 26 27 28 29 30 31 32 33 34 35 36	247	( $p$ <.001) and lower average health cost rates ( $p$ =.002) than higher staff turnover clinic-months.				
	248	(Table 1) Sensitivity analyses confirmed these results.				
	249	Lower turnover was always associated with reduced hospitalisation rates and, in almost all				
	250	instances, with savings in average health care costs compared to higher turnover. (Figure 1)				
	251	PC was cost-effective with ICER being \$1,708 per hospitalisation (savings in both numerator				
	252	and denominator). At the current NT threshold of \$4,213 per hospitalisation, the probability of				
37 38 39	253	lower turnover being more cost-effective is 1. (Figure 2)				
40 41	254					
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255	Table 1. Average health costs, hospitalisations, and incremental cost-effectiveness ratio
256	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-	High monthly turnover (≥10%)	45.3	51.7	17.8
	months)	Low monthly turnover (<10%)	34.6	38.4	16.0
		<i>p</i> -value	<.001	<.001	<.001
	Average health cost (\$) (per 1000 person-	High monthly turnover (≥10%)	\$491,043	\$531,865	\$446,344
	months)	Low monthly turnover (<10%)	\$472,826	\$511,977	\$440,355
	Incremental cost-	<i>p</i> -value	.002	.003	.271
	effectiveness ratio		\$1,708	\$1,500	\$3,365
257					
258					
259	2. Higher versus	lower proportional use of	agency-emplo	yed staff	
260	Remote clinic-mor	nths with higher proportional	use of agency-	employed nurses	have both a
261	significantly highe	r average health cost rate ( <i>p</i>	<.001) and high	ner YLLs rate (p<.	001) than clinic-
262	months with lower	use. (Table 2) Both sensitiv	ity analyses cor	nfirmed decreased	d effectiveness of
263	higher proportiona	al use of agency-employed n	urses. In remote	e Aboriginal com	nunities,
264	however, only ove	rall costs were higher in clini	ic-months that h	nad proportionally	lower use of
265	agency-employed	nurses.			
266	Lower proportiona	I use of agency nurses was	always associa	ted with health co	st savings
267	though less strong	gly associated with fewer YLI	Ls. (Figure 3) A	t the threshold va	lue of \$120,000
268	per YLL, the proba	ability of lower use of agency	-employed nurs	ses being more co	ost-effective was
269	0.849. (Figure 4)				
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# 272Table 2. Average health costs, years of life lost, and incremental cost-effectiveness ratio273for higher and lower proportional use of agency-employed nurses, 2013-15

		Total	Sensitivity analysis 1: Excluding predominantly non-Aboriginal communities	Sensitivity analysis Excluding hospitalisations fo 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-	High agency nurse proportion (≥10%)	14.4	13.5	14.4
months)	Low agency nurse proportion (<10%)	13.3	12.9	13.3
	<i>p</i> -value	<.001	.005	<.001
Average health cost (\$) (per 1000 person-	High agency nurse proportion (≥10%)	\$486,195	\$512,609	\$451,422
months)	Low agency nurse proportion (<10%)	\$458,086	\$521,809	\$423,543
	<i>p</i> -value	<.001	<.001	<.001
ICER		\$23,847	-\$13,837	\$23,652

#### 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.

1 2 3	288	Table 3. Multipl
5 6 7		
8 9		Number of hospi
10 11 12		10% increase in annual turnover
13 14 15		10% increase in agency nurses
17 17 18		Potentially preventially preventially preventions
20 21		Euclidian distand
22 23 24		Number of Prima consultations
25 26	289	** <i>p</i> <.001; AHP A
27 28	290	
29 30	291	Discussion
31 32 33	292	This landmark e
34 35	293	significantly lowe
36 37	294	consistently mor
38 39	295	of reducing staff
40 41	296	agency nurses h
42 43	297	important finding
44 45 46	298	investments in w
40 47 48	299	term agency nur
49 50	300	as well as to long
51 52	301	This research high
53 54	302	ordinated range
55 56 57	303	workforce, impro
58 59		

### Z88 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.

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 shortterm 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 coordinated range of short and longer term remote workforce strategies in order to stabilise the

303 workforce, improve continuity of care, and thereby improve health outcomes. Whilst our

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1 2			
3 4	304	kn	owledge about the effectiveness of various PC workforce retention interventions is incomplete
5 6 7	305	(2	1), available evidence suggests that effective short-term retention strategies include:
7 8 9	306	•	Ensuring necessary infrastructure, including adequate housing, vehicle, and communication
10 11	307		technologies;
12 13 14	308	٠	Offering realistic remuneration, including salary packaging and retention bonuses;
15 16	309	٠	Ensuring organisational effectiveness by (i) strengthening health service and clinic
17 18	310		management and leadership, (ii) ensuring comprehensive staff orientation and induction,
19 20	311		and (iii) maintaining a professional environment through mentoring, ongoing professional
21 22 23	312		development, and promoting scholarship;
24 25 26	313	•	Providing appropriate personal and family support for employees; and
27 28	314	•	Implementing alternative workforce models that are more likely to ensure continuity of care,
29 30	315		such as employing nurses to work one month on, one month off in shared positions.
31 32 33	316	Lo	nger-term retention strategies may include:
34 35	317	•	Providing sufficient funding (22, 23) to ensure an adequate supply of remote health
36 37 38	318		professionals relative to population needs without undue reliance on short-term staff;
39 40	319	٠	Increased recruitment of, and support for, Aboriginal people into clinical and non-clinical
41 42	320		roles. Training models which enable training of AHPs to be largely based in remote
43 44 45	321		communities may be effective;
46 47	322	•	Based on lessons learnt from the integrated rural medical training pathway, building
48 49	323		appropriate training pathways for remote area nurses in partnership with local educational
50 51	324		institutions, with a particular focus on appropriate student selection, a contextualised
52 53	325		program, and a supported post-graduate employment pathway. This is likely to result in a
54 55	326		better prepared and more stable nursing workforce;
50 57 58			15
59 60			10 For peer review only - http://bmiopen.bmi.com/site/about/quidelines.xhtml
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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 

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1 2			
3 4	352	cost-effective	e PC to be attained. This will require PC workforce turnover, retention, and use of
5 6 7	353	short-term st	aff to be addressed as a priority.
8 9 10	354	Conclusi	on
11 12	355	Higher reside	ent nurse and AHP turnover is costly and associated with poorer health outcomes
13 14	356	for Aborigina	I people. Halving the current annual turnover to 60% and reducing use of agency-
15 16	357	employed nu	irses has the potential to reduce costs to the NT health system by \$32 million each
17 18	358	year. Systen	nic investment in a range of co-ordinated workforce strategies is needed to stabilise
19 20	359	the remote v	vorkforce, save money, improve Aboriginal health outcomes and 'close the gap'.
21 22 23 24	360		
25 26 27	361	List of At	obreviations
28 29 30	362	ACCHS	Aboriginal Community Controlled Health Service
31 32	363	AHPs	Aboriginal Health Practitioners
33 34 35	364	DOH	Department of Health
36 37 38	365	DRG	Diagnosis-Related Group
39 40	366	FTE	Full-time Equivalent
41 42 43	367	GAS	Government Accounting System
44 45	368	HIA	Hospital Inpatients Activity
46 47 48	369	ICER	Incremental Cost-Effectiveness Ratio
49 50 51	370	NT	Northern Territory
52 53	371	PC	Primary Care
54 55 56	372	PCIS	Primary Care Information Systems
57 58			17
59 60			For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

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2 3 1	373	PIPS	Personnel Information and Payroll Systems
4 5 6	374	YLL	Year of Life Lost
7 8	375		
9 10	010		
11 12	376		
13 14	377	Declarat	ions
15 16 17	378	Ethics app	roval
18	379	Ethics appr	oval was received from the Human Research Ethics Committee of the Northern
19 20 21	380	Territory De	epartment of Health and Menzies School of Health Research (2015-2363).
22 23	381	Original pr	otocol for the study
24 25	382	The origina	I protocol for the study is published and available (open access):
26 27	383	Wakerman	J, Humphreys JS, Bourke L, Dunbar T, Jones M, Carey T, et al. Assessing the
28 29 30	384	impact and	cost of short-term health workforce in remote Indigenous communities in Australia: a
31 32	385	mixed meth	ods study protocol. JMIR research protocols. 2016;5(4):e135.
33 34	386	Funding	
35 36	387	This work v	vas supported by the Australian Research Council's Discovery Projects funding
37 38	388	scheme (pr	oject number DP150102227). The funder had no input in to the design, conduct and
39 40	389	reporting of	this analysis.
41 42	390	Competing	interests
43 44 45	391	The authors	s declare that they have no competing interests.
45 46	392	Data shari	ng statement
47 48	393	The datase	ts generated and analysed during the current study are not publicly available due to
49 50 51	394	identifiabilit	y of remote primary care providers and the need to protect their privacy.
51 52 53 54 55	395		
56 57			
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59 60			For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

#### 396 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.

#### 400 Acknowledgements

401 We wish to thank Steve Kyriacou and Barnie Kyriacou, who provided technical assistance in

- 402 accessing and interpreting Departmental data. We would also like to acknowledge and sincerely
- 403 thank all staff working in the 53 remote NT communities, particularly the clinic managers.
- 404 Finally, we would like to acknowledge the contributions of Terry Dunbar, David Lyle, Lisa
- 405 Bourke, Tim Carey and Lorna Murakami-Gold to the bigger, overarching research project,
- 406 especially for the qualitative research which helped inform our understanding of these
- 407 quantitative data and for comments provided which strengthened this manuscript.

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<sup>39</sup> 40 482	
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<sup>51</sup> 488 Figure 1. Cost-effectiveness plane comparing higher (≥10%) with lower (<10	%) monthly
<ul> <li>489 turnover rates in remote clinics</li> <li>55</li> <li>56</li> </ul>	
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4 5	491	Figure 2. Cost-effectiveness acceptability curve for comparing cost-effectiveness in
6 7	492	terms of saving hospitalisation costs between higher (≥10%) and lower (<10%) monthly
8 9 10	493	nurse and Aboriginal Health Practitioner turnover rates in remote clinics
10 11 12 13	494	
14 15	495	Figure 3. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%)
16 17	496	proportional use of agency-employed nurses in remote clinics
18 19 20	497	
21 22	498	Figure 4. Acceptability curve for comparing cost-effectiveness in terms of saving life-
23 24	499	years between higher (≥10%) and lower (<10%) proportional use of agency nurses in
25 26 27	500	remote clinics
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Figure 1. Cost-effectiveness plane comparing higher ( $\geq$ 10%) with lower (<10%) monthly turnover rates in remote clinics

297x209mm (300 x 300 DPI)



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

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1134x810mm (600 x 600 DPI)

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Simulations (bootstrap replicates)

- Threshold line



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

297x209mm (300 x 300 DPI)



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

	ltem		Reported on page No/
Section/item	No	Recommendation	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. Present the study question and its relevance for	page 3, line 61 to page 4, line 77 page 4, line 78 to 85
Methods		health policy or practice decisions.	
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

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	Item		Reported on page No/
Section/item	No	Recommendation	line No
	13b	Model-based economic evaluation: Describe	Not applicable
		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.	
Currency, price date, and	14	Report the dates of the estimated resource quantities	Page 5, line 102-
conversion		and unit costs. Describe methods for adjusting	103; page 5, line 111
		estimated unit costs to the year of reported costs if	to 113; page 7, line
		necessary. Describe methods for converting costs	154 to 156
		into a common currency base and the exchange rate.	
Choice of model	15	Describe and give reasons for the specific type of	page 14, line 293 to
		decision-analytical model used. Providing a figure to	294
		show model structure is strongly recommended.	
Assumptions	16	Describe all structural or other assumptions	Not applicable
		underpinning the decision-analytical model.	
Analytical methods	17	Describe all analytical methods supporting the	page 6, line 141 to
-		evaluation. This could include methods for dealing	page 8, line 183
		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.	
Results			
Study parameters	18	Report the values, ranges, references, and, if used,	page 8, line 170 to
, ,		probability distributions for all parameters. Report	173; page 8, line 177
		reasons or sources for distributions used to represent	to 178: page 9. line
		uncertainty where appropriate. Providing a table to	188 to 190
		show the input values is strongly recommended.	
Incremental costs and	19	For each intervention, report mean values for the	page 9, line 192 to
outcomes	20	main categories of estimated costs and outcomes of	194: page 10 Table
outcomes		interest as well as mean differences between the	1: nage 10 line 206
		comparator groups. If applicable report incremental	to 208: page 11
		cost-effectiveness ratios	Table 2
Charactorising uncortainty	202	Single study based economic evaluation: Describe the	Page 9 line 195 to
	20a	offects of campling uncertainty for the estimated	100: page 10 line
		incremental cost and incremental effectiveness	199, page 10, line
		noremental cost and incremental effectiveness	212 to 215; Figures 1
		methodological assumptions (such as discount rate	to 4; page 10, Table 2
		study perspective)	1; page 11, Table 2.
	201-	Study perspective).	Net en altrable
	200	Wodel-based economic evaluation: Describe the	Not applicable
		effects on the results of uncertainty for all input	
		parameters, and uncertainty related to the structure	
		of the model and assumptions.	
Characterising	21	If applicable, report differences in costs, outcomes, or	Not applicable
heterogeneity		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.	
Discussion			
Study findings,	22	Summarise key study findings and describe how they	page 12, line 238 to
limitations,		support the conclusions reached. Discuss limitations	page 15, line 299
gonoralisability and		and the generalisability of the findings and how the	
generalisability, and			

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	Item		Reported on page No/
Section/item	No	Recommendation	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 CH	IEERS state	ment checklist format is based on the format of the CON	ISORT 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

Journal:	BMJ Open
Manuscript ID	bmjopen-2018-023906.R1
Article Type:	Research
Date Submitted by the Author:	19-Oct-2018
Complete List of Authors:	Zhao, Yuejen; Health Gains Planning, Department of Health Russell, Deborah; Flinders University, College of Medicine and Public Health Guthridge, Steven; Menzies School of Health Research, Child Development, Population Health and Policy Ramjan, Mark; Northern Territory Department of Health Jones, Michael; Macquarie University, Psychology Department Humphreys, John; Monash University, School of Rural Health Wakerman, John; A Joint Centre of Flinders University and Charles Darwin University, Centre for Remote Health
<b>Primary Subject Heading</b> :	Health services research
Secondary Subject Heading:	Health economics, Health policy, Nursing, Public health
Keywords:	HEALTH ECONOMICS, Health economics < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Human resource management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT
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## SCHOLARONE<sup>™</sup> Manuscripts

1 2		
3 4	1	Costs and effects of higher turnover of nurses and Aboriginal Health
5 6	2	Practitioners and higher use of short-term nurses in remote
7 8	3	Australian primary care services: An observational cohort study
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1 2 3	59	Abstract
4 5		
6 7	60	
8 9	61	Objectives:
10 11	62	To compare the costs and effects of higher turnover of resident nurses and Aboriginal Health
12	63	Practitioners and higher use of agency-employed nurses in remote primary care services and
14 15	64	quantify associations between staffing patterns and health outcomes in remote primary care
16 17 18	65	clinics in the Northern Territory (NT) of Australia.
19 20 21	66	Design:
22 23	67	Observational cohort study, using hospital admission, financial, and payroll data for the period
24 25	68	2013-2015.
26 27 28	69	Setting:
29 30	70	53 NT Government run primary care clinics in remote communities.
31 32 33	71	Outcome measures:
34 35	72	Incremental cost-effectiveness ratios were calculated for higher compared with lower turnover
36 37	73	and higher compared with lower use of agency-employed nurses. Costs comprised primary
38 39	74	care, travel, and hospitalisation costs. Effect measures were total hospitalisations and years of
40 41 42	75	life lost per 1000 person-months. Multiple regression was performed to investigate associations
43 44	76	between overall health costs and turnover rates and use of agency-employed nurses, after
45 46 47 48 49 50 51	77	adjusting for key confounders.
	78	Results:
	79	Higher turnover was associated with significantly higher hospitalisation rates ( $p$ <0.001) and
52 53	80	higher average health costs (p=0.002) than lower turnover. Lower turnover was always more
54 55 56	81	cost-effective. Average costs were significantly ( $p$ <0.001) higher when higher proportions of
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> 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

1 2		
3 4	98	Article Summary
5	99	Strengths and limitations of this study
7	100	Data are for an entire population - remote living residents in communities serviced by
8 9 10	101	Northern Territory Department of Health;
10 11 12	102	Primary care and secondary care data are linked;
13 14	103	Univariate analyses (calculation of Incremental Cost-effectiveness Ratios) are
15 16	104	complemented by multiple regression analyses which adjust for key potential
17 18	105	confounders;
19 20	106	Analyses included assessing differences in costs and effects that were related to
21 22	107	hospital admissions for dialysis and demographic composition of communities
23 24 25	108	(predominantly non-Aboriginal or not);
25 26 27	109	• Effectiveness of primary care used proxy measures (hospitalisation rates; years of life
28 29	110	lost rates) which may not necessarily best reflect effectiveness of primary care.
30 31	111	
32 33	112	
34 35 36 37 38 39	113	Introduction
	114	There is an urgent need for high quality primary care (PC) services for disadvantaged Aborigina
40 41 42	115	and Torres Strait Islander populations (referred to as Aboriginal hereafter) in remote
43 44	116	communities of Australia. Australian Aboriginal peoples have higher levels of risk factors for
45 46	117	many communicable and non-communicable diseases and experience higher rates of complex
47 48	118	acute and chronic diseases such as infectious diseases, ischaemic heart disease, diabetes and
49 50	119	chronic kidney disease compared to non-Aboriginal Australians.(1-4) The gaps in life
51 52	120	expectancy at birth between Aboriginal and non-Aboriginal population in the Northern Territory
53 54	121	(NT) of Australia in 2009-13 were 15 and 16 years in males and females respectively.(5) In
55 56 57	122	2016, 30% of the NT population was Aboriginal and 70% of Aboriginal population lived in rural
58		5
59 60		For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Aboriginal

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1 2 3	400	
5 4 5 6 7	123	and remote areas.(6) Australian governments have committed to closing the gap in health
	124	outcomes between Aboriginal and non-Aboriginal Australians.(7)
7 8 9	125	In many remote NT communities, PC is mainly delivered by staff employed directly by the NT
10 11	126	Government. In these remote communities 'resident' staff comprise, on average, 2 nurses or
12 13	127	midwives (henceforth called nurses), 0.6 Aboriginal Health Practitioners (AHPs) and 2.2 other
14 15	128	employees all of whom live in the communities on a medium to long-term basis. Agency-
16 17	129	employed nurses provide, on average, 0.4 FTE of additional health manpower per clinic on a
18 19	130	short-term, fly-in fly-out basis.(8) District medical officers and allied health professionals provide
20 21	131	additional professional services to patients living in these remote communities through
22 23	132	intermittent scheduled visits and telehealth consultations.
24 25 26	133	Recent research shows that higher utilisation of PC services by Aboriginal people with chronic
27 28 29 30 31 32	134	diseases is cost-effective. Access to, and utilisation of, effective PC, however, may be
	135	compromised in remote NT communities by extremely high turnover rates of resident clinical
	136	staff and heavy reliance on short-term agency nurses.(8-10) Factors previously reported to be
33 34	137	associated with nurse turnover in NT include professional, social and geographical isolation, the
35 36 27	138	stressful work environment, unreasonably heavy workloads, lack of support from management
37 38 20	139	and inadequacy of housing.(11) NT Government initiatives in the past decade to decrease nurse
39 40 41	140	turnover have included changes to management practices to improve levels of support for
42 43	141	nurses, providing increased training and professional development opportunities, increasing the
44 45	142	flexibility of employment contracts and restructuring nursing classifications and increasing
46 47 48 49 50 51 52 53	143	remuneration.(12, 13)
	144	Primary care costs per person rise as geographical remoteness of communities increases and
	145	population size decreases.(14-16) A large proportion of these costs relates to higher staffing
	146	costs, and costs associated with staff and patients traveling long distances.(14, 17) Workforce
55 56	147	shortages and extremely high staff turnover (averaging 148% per annum for nurses) result in
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59 60		For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

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42% of NT remote area nurses being employed on relatively expensive casual or agencycontracts.(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 agencyemployed nurses on health care costs, after adjusting for known confounders.

#### 157 Methods

#### 158 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 agencyemployed nurses was used as a marker of overall use of short-term nurses.

#### 166 Patient involvement

167 This study comprised analysis of NT DOH secondary data (including individual-level de 168 identified hospitalisation and primary care data). Patients were not directly involved in data
 169 provision.

170 **Data** 

1

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2 3	171	Four NT DOH datasets were used: the Primary Care Information Systems (PCIS), Hospital
4 5	172	Inpatients Activity (HIA), Government Accounting System (GAS) and Personnel Information and
6 7 8 9 10	173	Payroll Systems (PIPS). The study period was 2013-2015, as this was the most recent period
	174	for which the required costs, hospitalisations, ages at death, use of agency-employed nurses
10 11 12	175	and workforce turnover data were available.(8)
13 14	176	PIPS data were used to calculate turnover rates of Department-employed purses and AHPs in
15 16	177	each month in each clinic (clinic-month):
17 18	177	
19 20	178	Turnover rate= $\frac{number of exits}{average number employed} x100$
21 22 23	179	An exit was defined when a staff member ceased working at a specific remote clinic for a period
23 24 25	180	of at least 12 weeks. A cut-off of 10% differentiated higher (≥10%) from lower (<10%) turnover,
26 27	181	equating to 120% annual turnover. Previous research showed that the average annual turnover
28 29 30 31 32 33 34 35 36	182	rate of nurses and AHPs in these remote NT clinics is 128%.(20)
	183	GAS data were used to calculate PC costs in Australian dollars for each clinic-month. PC clinic
	184	costs comprised operational and personnel expenditures and excluded capital expenses.
	185	Agency-employed nurse labour expenses were used to derive estimates of aggregated full-time
37 38	186	equivalent (FTE) agency-employed nurse use in each clinic-month using a standard NT DOH
39 40	187	formula:
41 42 43	188	Agency-employed nurse $FTE = \frac{Agency - employed nurse labour expenses}{2 \times average DOH - employed nurse cost}$ (21)
44 45 46 47 48 49 50 51	189	Percentage use of agency-employed nurses in each clinic-month was calculated:
	190	Percentage of agency-employed nurses= $\frac{Agency - employed nurse FTE}{Total FTE nurse positions} \times 100$
	191	A cut-off of 13% differentiated higher (≥13%) from lower (<13%) use of agency-employed
53 54	192	nurses as previous research shows that FTE agency-employed nurses fill, on average, 13% of
55 56	193	nurse positions.(8)
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1 2		
3 4	194	PCIS data were used to determine the number of PC consultations in each clinic-month.
5 6	195	Population catchments (service populations) for each remote clinic were defined as the number
7 8 0	196	of unique patients recorded in PCIS in the previous 12 months.
9 10 11	197	HIA data were used to determine the community in which each patient lived at the time of
12 13	198	hospital admission, to calculate the number of hospitalisations in each clinic-month, and to
14 15	199	estimate hospitalisation costs using information on diagnoses (Australian Refined Diagnosis-
16 17	200	Related Group (DRG) codes) provided in discharge summaries: (22)
18 19 20	201	Hospitalisation costs = $DRG cost weight \times NT$ benchmark prices .
21 22	202	Both HIA and PCIS data were used to determine age at death, from which Years of Life Lost
23 24	203	(YLLs) were calculated using an age specific life expectancy table used in the Australian Burden
25 26 27	204	of Disease study.(2)
28 29	205	Both GAS and PCIS data were used to estimate PC costs in each clinic-month, calculated by
30 31	206	first deriving an average consultation cost which was the overall estimated expenditure of the
32 33	207	clinic each year divided by the total occasions of service in that year. PC costs per person per
34 35	208	month (person-month) were calculated as the average consultation cost multiplied by the
36 37 28	209	number of consultations per person-month. Travel costs were calculated by doubling the
38 39 40	210	straight line distance between the resident community and nearest hospital, based on a flat rate
40 41 42	211	of \$2 per kilometre.(23)
43 44	212	Analyses
45 46	213	Two separate incremental cost-effectiveness ratios were calculated using clinic-month data. In
47 48	214	the first analysis (denoted in equations by subscript 1) comparison of costs and effects of higher
49 50	215	turnover clinic-months were compared with lower turnover rates, whereas in the second
51 52	216	analysis (subscript 2) costs and effects of clinic-months with higher use of agency-employed
53 54 55	217	nurses were compared with lower use of agency-employed nurses.
57 58		0
59 60		ع For peer review only - http://bmjopen.bmi.com/site/about/quidelines.xhtml
49 50 51 52 53 54 55 56 57 58 59 60	215 216 217	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. 9 For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Effects for the respective analyses were calculated as follows: Total number of hospitalisations Effect rate<sub>1</sub>= $\frac{1}{Total number of person - months}$ x1000 ; Total number of YLLs Effect rate<sub>2</sub>= $\frac{1}{Total number of person - months} \times 1000$ . 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: PC + Travel + Hospitalisation costs Costs rate=  $\frac{10^{-11} \text{ arter + Hospitalisation costs}}{Total number of person - months} \times 1000.$ 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: Costs rate in high turnover clinic – months – Costs rates in lower turnover clinic – months  $ICER_{1} = \frac{1}{Hospitalisation rate in high turnover clinic - months - Hospitalisation rate in lower turnover clinic - months}{ICER_{1} = \frac{1}{Hospitalisation rate in high turnover clinic - months}}$ 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: Costs in higher use of agency employed nurses clinic - months - Costs in lower use of agency employed nurses clinic - months ICER<sub>2</sub>=<sub>YLLs</sub> 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 For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

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240	1000 person-months. A 'top down' approach was used to allocate total remote health
241	expenditure to each clinic, as described elsewhere. All costs were based on actual expenditure.
242	In addition to calculating ICER point estimates, 2000 Bootstrap replicates were used to plot
243	cost-effectiveness planes (mean differences in the cost and effect pairs) and to construct cost-
244	effectiveness acceptability curves (probability that lower turnover or lower proportional use of
245	agency-employed nurses is cost-effective) to investigate uncertainty. Calculations of ICER also
246	examined variations in costs and effects if:
247	(1) clinics servicing predominantly non-Aboriginal communities were excluded;
248	(2) hospitalisations for renal dialysis were excluded; and
249	(3) only potentially preventable hospitalisations (PPH) were included.(24)
250	The average NT cost per hospitalisation of \$4,213 was used as the benchmark price for a
251	hospitalisation.(22) A threshold of \$120,000 was used as the benchmark price for a YLL.(25)
252	Multiple regression was used to investigate associations between overall costs and nurse and
253	AHP turnover rates and proportional use of agency-employed nurses, after adjusting for key
254	confounders. Potential confounders included Euclidean distance to the nearest hospital, PC
255	consultation rates, and hospitalisation rates (both total and PPH).
256	StataSE v14 was used for all analyses. A 0.05 level of statistical significance was used.
257	Ethics
258	Ethics approval was received from the Human Research Ethics Committee of the NT DOH and
259	Menzies School of Health Research (2015-2363).
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## **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

<sup>38</sup><sub>39</sub> 276 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

			Excluding predominantly		
			non-	Excluding	Potentially
		Total	Aboriginal	hospitalisations	preventable
	Monthly turnover	hospitalisations	communities	for renal dialysis	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-	Lower (<10%)	34.6	38.4	16.0	2.4
nonths)	<i>p</i> -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

Incremental cost- effectiveness ratio	us lower proportiona	\$1,708	\$1,500	\$3 365	
2. Higher versu	us lower proportiona			<i>43,303</i>	-\$107.830
2. Higher versu Remote clinic-m	us lower proportiona				
Remote clinic-m		al use of agency-en	nployed staff		
	onths with higher pro	portional use of age	ncy-employed	nurses hav	ve both a
significantly high	ner average health cos	st rate ( <i>p</i> <0.001) and	d higher YLLs	rate ( <i>p</i> <0.0	01) than
clinic-months wi	th lower use. (Table 2	?) Analyses examinir	ng variations i	n effects wh	ich excluded
predominantly n	on-Aboriginal commu	nities and excluded	renal dialysis	hospitalisat	ions
confirmed poore	er outcomes (greater \	YLLs rates) in clinic-i	months with h	igher propo	rtional use of
agency-employe	ed nurses. In remote A	Aboriginal communiti	ies (excluding	predomina	ntly non-
Aboriginal comm	nunities), however, ov	erall costs were high	ner in clinic-m	onths that h	ad
proportionally lo	wer use of agency-en	nployed nurses ( <i>p</i> <0	.001). PPHs a	analysis sho	owed no
significant differ	ences in YLLs betwee	en clinic-months with	higher and lo	wer proport	tional use of
agency-employe	ed nurses.				
For the analysis	of the total study pop	ulation, lower propo	rtional use of	agency nurs	ses was
always associat	ed with health cost sa	wings though less st	rongly associa	ated with fe	wer YLLs.
(Figure 3) At the	e threshold value of \$1	120,000 per YLL, the	e probability of	f lower use	of agency-
employed nurse	s being more cost-eff	ective was 0.838. (F	igure 4)		
	clinic-months wi predominantly n confirmed poore agency-employe Aboriginal comm proportionally lo significant differ agency-employe For the analysis always associat (Figure 3) At the employed nurse	clinic-months with lower use. (Table 2 predominantly non-Aboriginal commu confirmed poorer outcomes (greater V agency-employed nurses. In remote A Aboriginal communities), however, ov proportionally lower use of agency-en significant differences in YLLs betwee agency-employed nurses. For the analysis of the total study pop always associated with health cost sa (Figure 3) At the threshold value of \$7 employed nurses being more cost-effe	clinic-months with lower use. (Table 2) Analyses examining predominantly non-Aboriginal communities and excluded confirmed poorer outcomes (greater YLLs rates) in clinic- agency-employed nurses. In remote Aboriginal communit Aboriginal communities), however, overall costs were high proportionally lower use of agency-employed nurses ( <i>p</i> <0 significant differences in YLLs between clinic-months with agency-employed nurses. For the analysis of the total study population, lower propo- always associated with health cost savings though less st (Figure 3) At the threshold value of \$120,000 per YLL, the employed nurses being more cost-effective was 0.838. (F	clinic-months with lower use. (Table 2) Analyses examining variations in predominantly non-Aboriginal communities and excluded renal dialysis confirmed poorer outcomes (greater YLLs rates) in clinic-months with h agency-employed nurses. In remote Aboriginal communities (excluding Aboriginal communities), however, overall costs were higher in clinic-m proportionally lower use of agency-employed nurses ( <i>p</i> <0.001). PPHs a significant differences in YLLs between clinic-months with higher and lo agency-employed nurses. For the analysis of the total study population, lower proportional use of always associated with health cost savings though less strongly associa (Figure 3) At the threshold value of \$120,000 per YLL, the probability of employed nurses being more cost-effective was 0.838. (Figure 4)	clinic-months with lower use. (Table 2) Analyses examining variations in effects wh predominantly non-Aboriginal communities and excluded renal dialysis hospitalisat confirmed poorer outcomes (greater YLLs rates) in clinic-months with higher propo agency-employed nurses. In remote Aboriginal communities (excluding predomina Aboriginal communities), however, overall costs were higher in clinic-months that h proportionally lower use of agency-employed nurses ( <i>p</i> <0.001). PPHs analysis sho significant differences in YLLs between clinic-months with higher and lower proport agency-employed nurses. For the analysis of the total study population, lower proportional use of agency nurse always associated with health cost savings though less strongly associated with fer (Figure 3) At the threshold value of \$120,000 per YLL, the probability of lower use of 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-	Higher (≥13%)	14.6	13.7	14.6	0.0
months)	Lower (<13%)	13.3	12.8	13.3	0.1
	<i>p</i> -value	<0.001	<0.001	<0.001	0.978
Average health cost (\$) (per 1000 person-	Higher (≥13%)	\$480,915	\$503,989	\$446,289	\$301,567
months)	Lower (<13%)	\$470,145	\$532,494	\$435,375	\$295,207

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		<i>p</i> -value	<0.001	<0.001	<0.001	<0.001	
	ICER		\$7,964	-\$29,310	\$8,070	-\$70,757	
297							
298	3. Multiple	regression modelling	of overall cost rate	es			
299	Overall hea	Ith cost rates were signif	icantly associated v	with hospitalisation	ns, PPHs, P0	2	
300	consultation	is, turnover, use of agen	cy-employed nurse	s, and distance to	nearest hos	pital.	
301	(Table 3) Ea	ach 10% increase in ann	ual turnover was as	ssociated with an	increased co	st of \$11	
302	per person-	month. For each 10% in	crease in proportior	n of agency-emplo	yed nurses	used, there	
303	was an ass	ociated increase in cost	of \$10 per person-r	nonth. One PPH v	vas associat	ed with an	
304	increased c	ost of \$10,063, which wa	as in addition to the	costs of a normal	hospitalisati	on.	
305	Sensitivity a	nalyses (not shown) rev	ealed similar coeffi	cient estimates.			
306	Assuming a	service population of 35	5,000 residents, red	lucing turnover fro	m 120% per	annum to	
307	60% and no	longer using agency-er	nployed nurses (red	ducing from 13% t	o 0%) result	s in	
308	potential sa	potential savings of \$32 million annually in PC, hospitalisations, and travel costs.					
309							
310	Table 3. Mu	Itiple linear regressior	n model predicting	total health cos	ts per perso	on-month	
			Coefficient	95% CI Lower limit	95% CI U	Jpper limit	

	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
		<u> </u>	•

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

1 2 3	040	
4	312	
5 6 7	313	Discussion
8 9	314	This landmark empirical study shows that lower nurse and AHP turnover is associated with
10 11	315	significantly lower total hospitalisations ( $p$ <0.001), lower average health cost rates ( $p$ =0.002)
12 13	316	and is more cost-effective than higher turnover. The potential savings in health care costs of
14 15	317	reducing staff turnover are in the order of \$32 million annually. Also, lower use of short-term
16 17 18	318	agency nurses has an 84% likelihood of being more cost-effective than higher use.
19 20	319	For Aboriginal communities, PC cost rates were significantly higher in clinic-months that had
21 22	320	lower use of agency-employed nurses. This finding was, at face value, counter-intuitive, as
23 24	321	agency-employed labour hire is the most expensive staffing option. One possible explanation is
25 26 27	322	confounding of the association by geographical remoteness: the multiple linear regression
27 28 29	323	analysis confirmed that more geographically remote clinics have higher operating costs,
29 30 31	324	consistent with previous research.(14) More geographically remote clinics may also be more
32 33	325	likely to have lower use of agency nurses and incur even higher costs, for example because
34 35	326	agency-employed nurses may be less willing to work in the most geographically remote health
36 37	327	services. This research used regression analysis to confirm that health care costs in remote PC
38 39	328	clinics are positively and significantly associated with hospitalisations (total and PPH), nurse
40 41	329	and AHP turnover rates, use of agency-employed nurses, geographical remoteness and the
42 43 44	330	number of primary care consultations (Table 3).
45 46	331	These are important findings for policymakers and health service managers. The findings
47 48	332	suggest that effective investments in workforce strategies that reduce turnover rates and
49 50	333	decrease undue reliance on short-term agency nurses may have very significant net benefits,
51 52	334	both to the health services' budgets as well as to longer term health outcomes for
53 54 55 56	335	disadvantaged Aboriginal populations.
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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

354 the adoption of training models which enable AHP training to be largely based in remote

355 communities; building appropriate training pathways for remote area nurses in partnership with

356 local educational institutions, with a particular focus on appropriate student selection, a
 357 contextualised program, and a supported post-graduate employment pathway; and transitioning
 358 governance arrangements from NT Government-run to Aboriginal community control. While it is

governance analigements from NT Government-run to Aborginal community control. while it is

359 not known whether community-control of health services is associated with lower health

360 workforce turnover and lower use of short-term agency nurses, we do know that Aboriginal

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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-

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386	employed nurses) using existing administrative data. It is indicative of two simple workforce
387	policy scenarios in which cost-effectiveness information is otherwise lacking. No evidence
388	synthesis and decision modelling were undertaken in this study.
389	Despite its limitations, the findings of this research provide critically important evidence for
390	policymakers seeking to improve health outcomes for Aboriginal people living in remote
391	Australia while responsibly managing finite health budgets. There is great potential for more
392	cost-effective PC to be attained. This will require PC workforce turnover, retention, and use of
393	short-term agency-employed nurses to be addressed as a priority.
394	Conclusion
395	Higher turnover of government-employed nurses and AHPs is costly and associated with poorer
396	health outcomes for Aboriginal people. Halving the current annual turnover rate to 60% and
397	reducing use of agency-employed nurses has the potential to reduce costs to the NT health
398	system by \$32 million each year. Systemic investment in a range of co-ordinated workforce
399	strategies is needed to stabilise the remote workforce, save money, improve Aboriginal health
400	outcomes and 'close the gap'.
401 402	List of Abbreviations

- 403 AHPs Aboriginal Health Practitioners
- 7 404 DOH Department of Health
- 9 405 DRG Diagnosis-Related Group
- 2 406 FTE Full-time Equivalent
- 4 407 GAS Government Accounting System

1 2								
2 3 4	408	HIA	Hospital Inpatients Activity					
5 6 7	409	ICER	Incremental Cost-Effectiveness Ratio					
8 9	410	NT	Northern Territory					
10 11 12	411	PC	Primary Care					
13 14	412	PCIS	Primary Care Information Systems					
15 16 17	413	PIPS	Personnel Information and Payroll Systems					
18 19 20	414	PPH	Potentially Preventable Hospitalisation					
20 21 22	415	YLL	Year of Life Lost					
23 24 25	416							
26 27	417	Declarations						
28 29 30	418	Ethics approval						
31	419	Ethics approv	val was received from the Human Research Ethics Committee of the Northern					
32 33 34	420	Territory Department of Health and Menzies School of Health Research (2015-2363).						
35 36	421	Original protocol for the study						
37 38	422	The original protocol for the study is published and available (open access):						
39 40 41	423	Wakerman J, Humphreys JS, Bourke L, Dunbar T, Jones M, Carey T, et al. Assessing the						
42	424	impact and c	ost of short-term health workforce in remote Indigenous communities in Australia: a					
43 44 45	425	mixed methods study protocol. JMIR research protocols. 2016;5(4):e135.						
46 47	426	Funding						
48	427	This work wa	s supported by the Australian Research Council's Discovery Projects funding					
49 50 51	428	scheme (project number DP150102227). The funder had no input in to the design, conduct and						
52 53	429	reporting of t	his analysis.					
54 55 56	430	Competing i	nterests					
57 58			19					
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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. Acknowledgements

The authors thank NT Department of Health staff who provided technical assistance in accessing and interpreting Northern Territory (NT) Department of Health personnel, primary care, hospitalisation and financial data. The authors also acknowledge and sincerely thank all staff working in the 54 remote NT communities, particularly the clinic managers. Finally, the authors would acknowledge the contributions of Terry Dunbar, Lisa Bourke, Lorna Murakami-Gold, Tim Carey and David Lyle to the bigger overarching research project and for comments that strengthened this manuscript.

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2 3 4	528	
5 6	529	Figure Titles
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8 9 10	531	Figure 1. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%) monthly
11 12	532	turnover rates in remote clinics
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14 15	524	Figure 2. Cost offectiveness acceptebility surve for comparing costs and offects in
16	534	Figure 2. Cost-effectiveness acceptability curve for comparing costs and effects in
17 18	535	savings in total health costs between higher (≥10%) and lower (<10%) monthly nurse and
19 20	536	Aboriginal Health Practitioner turnover rates in remote clinics
21 22 23	537	
24 25	538	Figure 3. Cost-effectiveness plane comparing higher (≥10%) with lower (<10%)
26 27 28	539	proportional use of agency-employed nurses in remote clinics
28 29 30 31	540	
32 33	541	Figure 4. Acceptability curve for comparing costs and effects in terms of saving life-
34 35	542	years between higher (≥10%) and lower (<10%) proportional use of agency nurses in
36 37	543	remote clinics
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## CHEERS checklist—Items to include when reporting economic evaluations of health interventions

	ltem		Reported on page No/
Section/item	No	Recommendation	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. Present the study question and its relevance for	page 3, line 61 to page 4, line 77 page 4, line 78 to 85
Methods		health policy or practice decisions.	
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

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	Item		Reported on page No/
Section/item	No	Recommendation	line No
	13b	Model-based economic evaluation: Describe	Not applicable
		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.	
Currency, price date, and	14	Report the dates of the estimated resource quantities	Page 5, line 102-
conversion		and unit costs. Describe methods for adjusting	103; page 5, line 111
		estimated unit costs to the year of reported costs if	to 113; page 7, line
		necessary. Describe methods for converting costs	154 to 156
		into a common currency base and the exchange rate.	
Choice of model	15	Describe and give reasons for the specific type of	page 14, line 293 to
		decision-analytical model used. Providing a figure to	294
		show model structure is strongly recommended.	
Assumptions	16	Describe all structural or other assumptions	Not applicable
		underpinning the decision-analytical model.	
Analytical methods	17	Describe all analytical methods supporting the	page 6, line 141 to
		evaluation. This could include methods for dealing	page 8, line 183
		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.	
Results			
Study parameters	18	Report the values, ranges, references, and, if used,	page 8, line 170 to
, ,		probability distributions for all parameters. Report	173; page 8, line 177
		reasons or sources for distributions used to represent	to 178: page 9. line
		uncertainty where appropriate. Providing a table to	188 to 190
		show the input values is strongly recommended.	
Incremental costs and	19	For each intervention, report mean values for the	page 9, line 192 to
outcomes		main categories of estimated costs and outcomes of	194: page 10 Table
outcomes		interest as well as mean differences between the	1: nage 10 line 206
		comparator groups. If applicable report incremental	to 208: page 11
		cost-effectiveness ratios	Table 2
Characterising uncertainty	202	Single study-based economic evaluation: Describe the	Page Q line 195 to
	20a	offects of campling uncertainty for the estimated	
		incremental cost and incremental effectiveness	199, page 10, line
		noremental cost and incremental effectiveness	212 to 215; Figures 1
		methodological assumptions (such as discount rate	to 4; page 10, Table 2
		study perspective)	1; page 11, Table 2.
	204	Madal based economic suglustion: Describe the	Natanaliaahla
	200	Model-based economic evaluation: Describe the	Not applicable
		effects on the results of uncertainty for all input	
		af the model and accurations	
	24	of the model and assumptions.	
Characterising	21	If applicable, report differences in costs, outcomes, or	Not applicable
heterogeneity		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.	
Discussion			
Study findings,	22	Summarise key study findings and describe how they	page 12, line 238 to
limitations,		support the conclusions reached. Discuss limitations	page 15, line 299
generalisability, and		and the generalisability of the findings and how the	
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	Item		Reported on page No/
Section/item	No	Recommendation	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 CHE	EERS state	ment checklist format is based on the format of the CON	ISORT statement checklist