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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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4 **1 The impacts of higher turnover and higher use of short-term staff on**
5 **2 the cost-effectiveness of remote Australian primary care services**

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2
3 58 **Abstract**
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8 60 **Objectives:**
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10 61 To compare the cost-effectiveness of:

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13 62 i. higher with lower turnover of resident nurses and Aboriginal Health Practitioners; and

14
15 63 ii. higher with lower use of agency-employed nurses;

16
17
18 64 and quantify associations between health care costs and staffing patterns in remote Northern
19
20 65 Territory community primary care clinics.
21
22

23 66 **Design:**
24

25 67 Observational cohort study, using hospital admission, financial, and payroll data for the period
26
27 68 2013-2015
28
29

30 69 **Setting:**
31

32
33 70 53 Northern Territory Government (Australia) run primary care clinics in remote communities
34
35

36 71 **Outcome measures:**
37

38 72 Incremental cost-effectiveness ratios were calculated for i. higher compared with lower turnover;
39
40 73 and ii. higher compared with lower use of agency-employed nurses. Costs comprised primary
41
42 74 care, travel, and hospitalisation costs. Effectiveness measures were i. total hospitalisations and
43
44 75 ii. years of life lost per 1000 person-months. Multiple regression was performed to investigate
45
46 76 associations between overall costs and turnover rates and use of agency-employed nurses,
47
48 77 after adjusting for key confounders.
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50

51 78 **Results:**
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3 79 Higher turnover was associated with significantly higher hospitalisation rates ($p<.001$) and
4
5 80 higher average health costs ($p=.002$) than lower turnover. Lower turnover was always more
6
7 81 cost-effective.
8

9
10 82 Average costs were significantly ($p<.001$) higher when higher proportions of agency-employed
11
12 83 nurses were employed. The probability that lower use of agency-employed nurses was more
13
14 84 cost-effective was 0.85.
15

16
17 85 Halving turnover and reducing use of a short-term workforce has the potential to save \$32
18
19 86 million annually in the Northern Territory.
20

21 87 **Conclusion**

22
23
24 88 High turnover of health staff is costly and associated with poorer health outcomes for Aboriginal
25
26 89 peoples living in remote communities. High reliance on agency nurses is also very likely to be
27
28 90 cost-*ineffective*. Investment in a coordinated range of workforce strategies that support
29
30 91 recruitment and retention of resident nurses and Aboriginal Health Practitioners in remote clinics
31
32 92 is needed to stabilise the workforce and thereby significantly reduce expenditure and improve
33
34 93 health outcomes.
35
36

37 94

38 39 40 95 **Keywords**

41
42 96 Remote health, Health workforce, Turnover, Remote area nurse, Aboriginal Health Practitioner,
43
44 97 Fly-in fly-out, Remote health services, Health manpower, Indigenous health
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46

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48 99

100 **Article Summary**

101 **Strengths and limitations of this study**

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

115 **Introduction**

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

1
2
3 125 communities by extremely high turnover rates of resident clinical staff and heavy reliance on
4
5 126 short-term agency nurses.(7-9) Primary care costs per person rise as geographical remoteness
6
7 127 of communities increases and population size decreases.(10-12) A large proportion of these
8
9 128 costs relates to higher staffing costs, and costs associated with staff and patients traveling long
10
11 129 distances.(10, 13) Workforce shortages and extremely high staff turnover (averaging 148% per
12
13 130 annum for nurses) result in 42% of NT remote area nurses being employed on relatively
14
15 131 expensive casual or agency contracts.(7, 10, 12, 14)

16
17
18 132 There is a lack of published quantitative evidence, however, of the costs, effectiveness, and
19
20 133 cost-effectiveness of different staffing patterns.(15) The aims of this research, therefore, are
21
22 134 threefold: first, to compare the cost-effectiveness of higher turnover of resident remote area
23
24 135 nurses or midwives (nurses) and Aboriginal Health Practitioners (AHPs) with lower turnover;
25
26 136 second, to compare the cost-effectiveness of proportionally higher use of agency-employed
27
28 137 nurses with lower use of agency-employed nurses; and, third, to quantify the effects of nurse
29
30 138 and AHP turnover and use of agency-employed nurses on health care costs, after adjusting for
31
32 139 known confounders.

33 34 35 36 140 **Methods**

37 38 39 141 **Study setting**

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41
42 142 The study sites were 53 NT Department of Health (DOH) remote health clinics in 46
43
44 143 predominantly Aboriginal communities and 7 non-Indigenous towns where resident nurses,
45
46 144 AHPs, and Aboriginal community workers provide most clinical PC services.(7) Temporary and
47
48 145 ongoing nursing and AHP vacancies were filled by DOH employed casual nurses, DOH
49
50 146 employed agency nurses or, as the least preferred, most expensive alternative, by agency-
51
52 147 employed nurses (nurses paid directly by nurse employment agencies). In this study the
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148 proportion of agency-employed nurses was used as a marker of overall use of short-term
149 nurses.

150 **Patient involvement**

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

153 **Data**

154 Four NT DOH datasets were used: the Primary Care Information Systems (PCIS), Hospital
155 Inpatients Activity (HIA), Government Accounting System (GAS) and Personnel Information and
156 Payroll Systems (PIPS). The study period was 2013-2015, as this was the most recent period
157 for which the required costs, effectiveness and workforce turnover data were available.(7)
158 PIPS data were used to calculate monthly turnover rates of nurses and AHPs in each month in
159 each clinic:

$$160 \text{ Turnover rate} = \frac{\text{number of exits}}{\text{average number employed}} \times 100$$

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

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

$$170 \text{ Agency-employed nurse FTE} = \frac{\text{Agency-employed nurse labour expenses}}{2 \times \text{average DOH-employed nurse cost}} \quad (17)$$

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3 171 Percentage use of agency-employed nurses at each clinic each month was calculated:
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5
6 172 Percentage of agency-employed nurses = $\frac{\text{Agency-employed nurse FTE}}{\text{Total FTE nurse positions}} \times 100$
7

8
9 173 A cut-off of 10% differentiated higher ($\geq 10\%$) from lower ($< 10\%$) use of agency-employed
10
11 174 nurses. Previous research showed that FTE agency-employed nurses filled, on average, 13% of
12
13 175 nurse positions.(7)
14

15
16 176 PCIS data were used to determine the number of PC consultations in each clinic each month.
17

18 177 Population catchments (service populations) for each remote clinic were defined as the number
19
20 178 of unique patients recorded in PCIS in the previous 12 months.
21

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
27 181 to estimate hospitalisation costs using information on diagnoses (Australian Refined Diagnosis-
28
29 182 Related Group (DRG) codes) provided in discharge summaries: (18)
30

31
32 183 Hospitalisation costs = $DRG \text{ cost weight} \times NT \text{ benchmark prices}$.
33

34 184 Both HIA and PCIS data were used to determine age at death, from which Years of Life Lost
35
36 185 (YLLs) were calculated using an age specific life expectancy table used in the Australian Burden
37
38 186 of Disease study.(2)
39

40
41 187 Both GAS and PCIS data were used to estimate PC costs each month in each clinic, calculated
42
43 188 by first deriving an average consultation cost which was the overall estimated expenditure of the
44
45 189 clinic each year divided by the total occasions of service in that year. PC costs per person per
46
47 190 month were calculated as the average consultation cost multiplied by the number of
48
49 191 consultations per person-month. Travel costs were calculated by doubling the straight line
50
51 192 distance between the resident community and nearest hospital, based on a flat rate of \$2 per
52
53 193 kilometre.(19)
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194 **Analyses**

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

199 Effects for the respective analyses were calculated as follows:

$$200 \quad \text{Effect}_1 = \frac{\text{Total number of hospitalisations}}{\text{Total number of person-months}} \times 1000 ;$$

$$201 \quad \text{Effect}_2 = \frac{\text{Total number of YLLs}}{\text{Total number of person-months}} \times 1000 .$$

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

206 Costs for the respective analyses were calculated as follows:

$$207 \quad \text{Costs}_{1,2} = \frac{\text{PC} + \text{Travel} + \text{Hospitalisation costs}}{\text{Total number of person-months}} \times 1000.$$

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

$$214 \quad \text{ICER}_1 = \frac{\text{Costs in high turnover clinic months} - \text{Costs in lower turnover clinic months}}{\text{Effects in high turnover clinic months} - \text{Effects in lower turnover clinic months}}$$

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2
3 215 The ICER for the second analysis was calculated as the difference in average health costs per
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5 216 1000 person-months, divided by the difference in effects (YLLs) per 1000 person-months:

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8 217
$$\text{ICER}_2 = \frac{\text{Costs in higher use of agency employed nurses clinic months} - \text{Costs in lower use of agency employed nurses clinic months}}{\text{Effects in higher use of agency employed nurses clinic months} - \text{Effects in lower use of agency employed nurses clinic months}}$$

9

10
11 218 Overall hospitalisation rates and YLLs rates were proxies for PC effectiveness in the first and
12
13 219 second analyses, respectively. In both analyses the perspective of the NT Government was
14
15 220 used to identify relevant costs incurred, which included PC, travel, and hospitalisation costs per
16
17 221 1000 person-months. A 'top down' approach was used to allocate total remote health
18
19 222 expenditure to each clinic, as described elsewhere.(12) All costs were based on actual
20
21 223 expenditure.

22
23
24 224 In addition to calculating ICER point estimates, 2000 Bootstrap replicates were used to plot
25
26 225 cost-effectiveness planes (mean differences in the cost and effect pairs) and to construct cost-
27
28 226 effectiveness acceptability curves (probability that lower turnover or lower proportional use of
29
30 227 agency-employed nurses is cost-effective) to investigate uncertainty. Calculations of ICER also
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32 228 included two sensitivity analyses, to examine costs and effects if:

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35 229 (1) clinics servicing predominantly non-Aboriginal communities were excluded; and

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37
38 230 (2) hospitalisations for renal dialysis were excluded.

39
40 231 The average NT cost per hospitalisation of \$4,213 was used as the benchmark price for a
41
42 232 hospitalisation.(18) A threshold of \$120,000 was used as the benchmark price for a YLL.(20)

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45 233 Multiple regression was used to investigate associations between overall costs and nurse and
46
47 234 AHP turnover rates and proportional use of agency-employed nurses, after adjusting for key
48
49 235 confounders. Potential confounders included Euclidean distance to the nearest hospital, PC
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51 236 consultation rates, and hospitalisation rates (both total and potentially preventable).

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54 237 StataSE v14 was used for all analyses. A .05 level of statistical significance was used.
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3 238 **Ethics**
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6 239 Ethics approval was received from the Human Research Ethics Committee of the NT DOH and
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8 240 Menzies School of Health Research (2015-2363).
9

10
11 241 **Results**
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14 242 Between 2013 and 2015 there were 1,266,708 person-months, 46,276 hospital admissions,
15
16 243 2,058,829 PC consultations, and a service population of approximately 35,000 persons. Total
17
18 244 health costs were \$603 million and there were 530 deaths with an estimated 17,750 YLLs.
19

20
21 245 **1. Higher versus lower turnover**
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23 246 Remote clinic-months with lower staff turnover have both significantly lower hospitalisation rates
24
25 247 ($p<.001$) and lower average health cost rates ($p=.002$) than higher staff turnover clinic-months.
26
27 248 (Table 1) Sensitivity analyses confirmed these results.
28

29 249 Lower turnover was always associated with reduced hospitalisation rates and, in almost all
30
31 250 instances, with savings in average health care costs compared to higher turnover. (Figure 1)
32
33 251 PC was cost-effective with ICER being \$1,708 per hospitalisation (savings in both numerator
34
35 252 and denominator). At the current NT threshold of \$4,213 per hospitalisation, the probability of
36
37 253 lower turnover being more cost-effective is 1. (Figure 2)
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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 ($\geq 10\%$)	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 ($\geq 10\%$)	45.3	51.7	17.8
	Low monthly turnover ($< 10\%$)	34.6	38.4	16.0
	<i>p</i> -value	$< .001$	$< .001$	$< .001$
Average health cost (\$) (per 1000 person- months)	High monthly turnover ($\geq 10\%$)	\$491,043	\$531,865	\$446,344
	Low monthly turnover ($< 10\%$)	\$472,826	\$511,977	\$440,355
	<i>p</i> -value	.002	.003	.271
Incremental cost-effectiveness ratio		\$1,708	\$1,500	\$3,365

257

258

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

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

266 Lower proportional use of agency nurses was always associated with health cost savings
 267 though less strongly associated with fewer YLLs. (Figure 3) At the threshold value of \$120,000
 268 per YLL, the probability of lower use of agency-employed nurses being more cost-effective was
 269 0.849. (Figure 4)

270

271

272 **Table 2. Average health costs, years of life lost, and incremental cost-effectiveness ratio**
 273 **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 ($\geq 10\%$)	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 ($\geq 10\%$)	14.4	13.5	14.4
	Low agency nurse proportion ($< 10\%$)	13.3	12.9	13.3
	<i>p</i> -value	$< .001$.005	$< .001$
Average health cost (\$) (per 1000 person- months)	High agency nurse proportion ($\geq 10\%$)	\$486,195	\$512,609	\$451,422
	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

274

275 3. Multiple regression modelling of overall cost rates

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

284 Assuming a service population of 35,000 residents, reducing turnover from 120% per annum to
 285 60% and no longer using agency-employed nurses (reducing from 13% to 0%) results in
 286 potential savings of \$32 million annually in PC, hospitalisations, and travel costs.

287

288 **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

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

290

291 Discussion

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

301 This research highlights a pressing need to invest in the systematic implementation of a co-
 302 ordinated 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

1
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3 304 knowledge about the effectiveness of various PC workforce retention interventions is incomplete

4
5 305 (21), available evidence suggests that effective short-term retention strategies include:

6
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8 306 • Ensuring necessary infrastructure, including adequate housing, vehicle, and communication
9
10 307 technologies;

11
12 308 • Offering realistic remuneration, including salary packaging and retention bonuses;

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15 309 • Ensuring organisational effectiveness by (i) strengthening health service and clinic
16
17 310 management and leadership, (ii) ensuring comprehensive staff orientation and induction,
18
19 311 and (iii) maintaining a professional environment through mentoring, ongoing professional
20
21 312 development, and promoting scholarship;

22
23
24 313 • Providing appropriate personal and family support for employees; and

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26
27 314 • Implementing alternative workforce models that are more likely to ensure continuity of care,
28
29 315 such as employing nurses to work one month on, one month off in shared positions.

30
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32 316 Longer-term retention strategies may include:

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34 317 • Providing sufficient funding (22, 23) to ensure an adequate supply of remote health
35
36 318 professionals relative to population needs without undue reliance on short-term staff;

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38
39 319 • Increased recruitment of, and support for, Aboriginal people into clinical and non-clinical
40
41 320 roles. Training models which enable training of AHPs to be largely based in remote
42
43 321 communities may be effective;

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45
46 322 • Based on lessons learnt from the integrated rural medical training pathway, building
47
48 323 appropriate training pathways for remote area nurses in partnership with local educational
49
50 324 institutions, with a particular focus on appropriate student selection, a contextualised
51
52 325 program, and a supported post-graduate employment pathway. This is likely to result in a
53
54 326 better prepared and more stable nursing workforce;

- 1
2
3 327 • Transitioning governance arrangements from NT Government-run to Aboriginal community
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5 328 control. While it is not known whether community-control of health services is associated
6
7 329 with lower health workforce turnover and lower use of short-term agency nurses, we do
8
9 330 know that Aboriginal Community Controlled Health Services (ACCHSs) employ a high
10
11 331 proportion of Aboriginal staff (24), and that family connections (25) and a sense of
12
13 332 ownership of the service (26) contribute to improved access. (27, 28)
14
15

16 333 This study is not without some limitations. Estimates of the effectiveness of PC used proxy
17
18 334 measures, which may not necessarily best reflect effectiveness of PC. Comparison groups for
19
20 335 cost-effectiveness analyses were also somewhat arbitrarily defined and it would have been
21
22 336 preferable to make comparisons on the basis of use of all agency nurses, not just of agency-
23
24 337 employed nurses. However, we were not able to accurately identify DOH-employed agency
25
26 338 nurses within the payroll data. Our cost estimates may also be imprecise, as they are
27
28 339 dependent on the quality of administrative data on expenditure recorded in GAS and on
29
30 340 consultation data recorded in PCIS. Our study also did not include effects of any policy
31
32 341 measures designed to reduce staff turnover, nor did it attempt to measure the costs of
33
34 342 introducing such policies. While the findings of our study are likely generalisable to other
35
36 343 primary care clinics in remote, predominantly Aboriginal communities in Australia, caution is
37
38 344 advised in generalising beyond these limits. This is an observational study comparing two
39
40 345 different situations (higher vs lower turnover; higher vs lower proportional use of agency-
41
42 346 employed nurses) using existing administrative data. It is indicative of two simple workforce
43
44 347 policy scenarios in which cost-effectiveness information is otherwise lacking. No evidence
45
46 348 synthesis and decision modelling were undertaken in this study.
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50 349 Despite its limitations, the findings of this research provide critically important evidence for
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52 350 policymakers seeking to improve health outcomes for Aboriginal people living in remote
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54 351 Australia while responsibly managing finite health budgets. There is great potential for more
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352 cost-effective PC to be attained. This will require PC workforce turnover, retention, and use of
353 short-term staff to be addressed as a priority.

354 **Conclusion**

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

360

361 **List of Abbreviations**

362 ACCHS Aboriginal Community Controlled Health Service

363 AHPs Aboriginal Health Practitioners

364 DOH Department of Health

365 DRG Diagnosis-Related Group

366 FTE Full-time Equivalent

367 GAS Government Accounting System

368 HIA Hospital Inpatients Activity

369 ICER Incremental Cost-Effectiveness Ratio

370 NT Northern Territory

371 PC Primary Care

372 PCIS Primary Care Information Systems

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3 373 PIPS Personnel Information and Payroll Systems
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6 374 YLL Year of Life Lost
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12 13 377 **Declarations** 14 15

16 378 **Ethics approval**

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18 379 Ethics approval was received from the Human Research Ethics Committee of the Northern
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20 380 Territory Department of Health and Menzies School of Health Research (2015-2363).
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22 381 **Original protocol for the study**

23
24 382 The original protocol for the study is published and available (open access):
25

26 383 Wakerman J, Humphreys JS, Bourke L, Dunbar T, Jones M, Carey T, et al. Assessing the
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28 384 impact and cost of short-term health workforce in remote Indigenous communities in Australia: a
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30 385 mixed methods study protocol. JMIR research protocols. 2016;5(4):e135.
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32

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38
39 389 reporting of this analysis.
40

41 390 **Competing interests**

42
43 391 The authors declare that they have no competing interests.
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45

46 392 **Data sharing statement**

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48 393 The datasets generated and analysed during the current study are not publicly available due to
49
50 394 identifiability of remote primary care providers and the need to protect their privacy.
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3 396 **Author contributions**

4 397 This research was conceived by JW, JH, SG, YZ and MJ. YZ led the analysis. All authors
5
6 398 contributed to the planning and coordination of the study, interpretation of the data and drafting
7
8
9 399 of the manuscript. All authors read and approved the final manuscript.

10
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Figure Titles

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

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5 491 **Figure 2. Cost-effectiveness acceptability curve for comparing cost-effectiveness in**
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9 493 **nurse and Aboriginal Health Practitioner turnover rates in remote clinics**

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14 495 **Figure 3. Cost-effectiveness plane comparing higher ($\geq 10\%$) with lower ($< 10\%$)**
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16 496 **proportional use of agency-employed nurses in remote clinics**

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21 498 **Figure 4. Acceptability curve for comparing cost-effectiveness in terms of saving life-**
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23 499 **years between higher ($\geq 10\%$) and lower ($< 10\%$) proportional use of agency nurses in**
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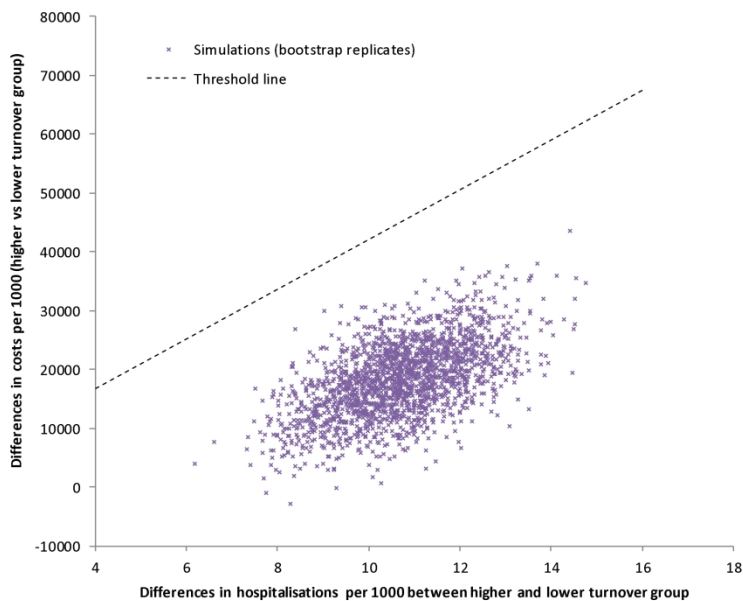


Figure 1. Cost-effectiveness plane comparing higher ($\geq 10\%$) with lower ($< 10\%$) monthly turnover rates in remote clinics

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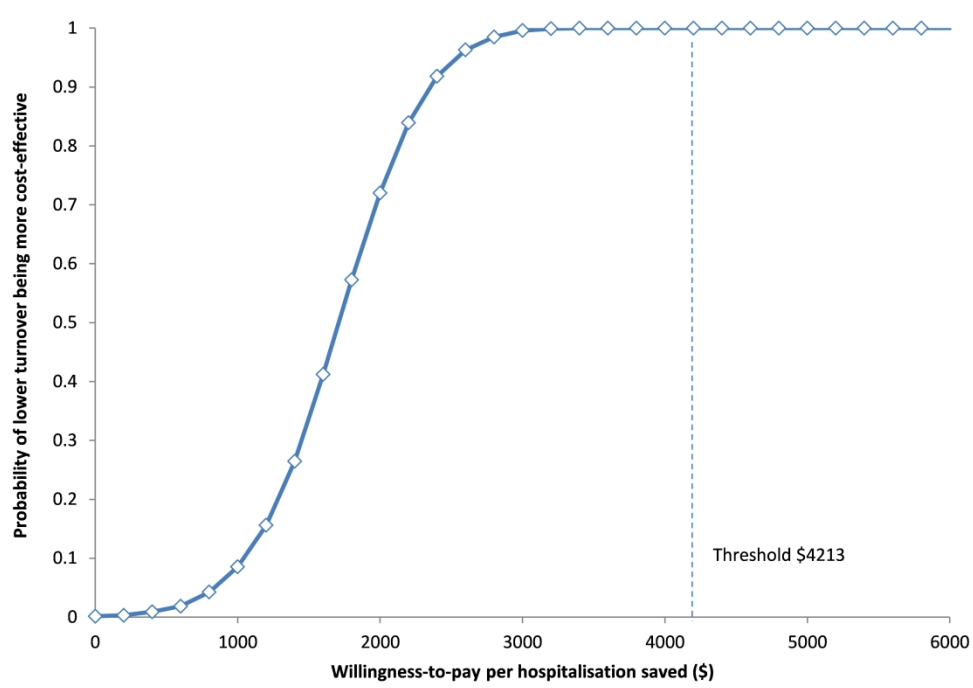


Figure 2. Cost-effectiveness acceptability curve for comparing cost-effectiveness in terms of saving hospitalisation costs between higher ($\geq 10\%$) and lower ($< 10\%$) monthly nurse and Aboriginal Health Practitioner turnover rates in remote clinics

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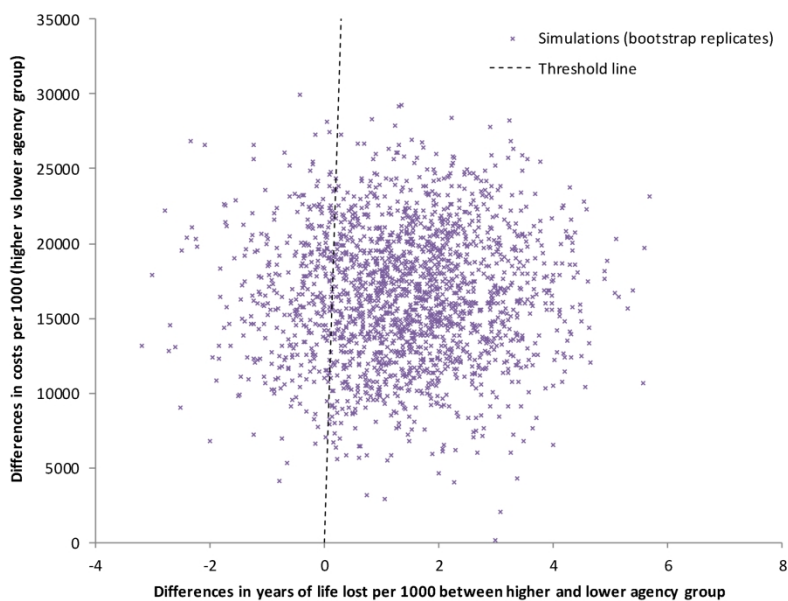


Figure 3. Cost-effectiveness plane comparing higher ($\geq 10\%$) with lower ($< 10\%$) proportional use of agency-employed nurses in remote clinics

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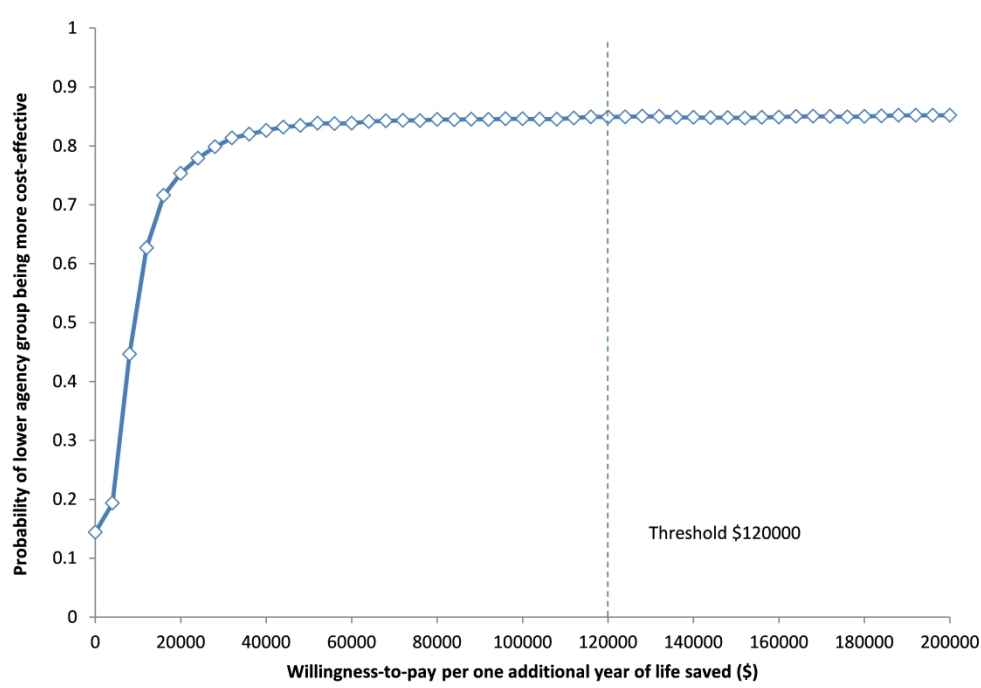


Figure 4. Acceptability curve for comparing cost-effectiveness in terms of saving life-years between higher ($\geq 10\%$) and lower ($< 10\%$) proportional use of agency nurses in remote clinics

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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	<i>Single study-based estimates</i> : 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	<i>Synthesis-based estimates</i> : 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	<i>Single study-based economic evaluation</i> : 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	<i>Model-based economic evaluation:</i> 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	<i>Single study-based economic evaluation:</i> 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	<i>Model-based economic evaluation:</i> 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

Journal:	<i>BMJ Open</i>
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
Primary Subject Heading:	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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Manuscripts

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4 1 **Costs and effects of higher turnover of nurses and Aboriginal Health**
5 2 **Practitioners and higher use of short-term nurses in remote**
6 3 **Australian primary care services: An observational cohort study**
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26 40 **Word count**

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3 **59 Abstract**
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8 **61 Objectives:**
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10 62 To compare the costs and effects of higher turnover of resident nurses and Aboriginal Health
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12 63 Practitioners and higher use of agency-employed nurses in remote primary care services and
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14 64 quantify associations between staffing patterns and health outcomes in remote primary care
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16 65 clinics in the Northern Territory (NT) of Australia.
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19 66 **Design:**
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22 67 Observational cohort study, using hospital admission, financial, and payroll data for the period
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24 68 2013-2015.
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26 69 **Setting:**
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29 70 53 NT Government run primary care clinics in remote communities.
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32 71 **Outcome measures:**
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34 72 Incremental cost-effectiveness ratios were calculated for higher compared with lower turnover
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36 73 and higher compared with lower use of agency-employed nurses. Costs comprised primary
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38 74 care, travel, and hospitalisation costs. Effect measures were total hospitalisations and years of
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40 75 life lost per 1000 person-months. Multiple regression was performed to investigate associations
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42 76 between overall health costs and turnover rates and use of agency-employed nurses, after
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44 77 adjusting for key confounders.
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47 78 **Results:**
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50 79 Higher turnover was associated with significantly higher hospitalisation rates ($p<0.001$) and
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52 80 higher average health costs ($p=0.002$) than lower turnover. Lower turnover was always more
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54 81 cost-effective. Average costs were significantly ($p<0.001$) higher when higher proportions of
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3 82 agency-employed nurses were employed. The probability that lower use of agency-employed
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5 83 nurses was more cost-effective was 0.84. Halving turnover and reducing use of a short-term
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7 84 workforce has the potential to save \$32 million annually in the NT.
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10 85 **Conclusion**

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12 86 High turnover of health staff is costly and associated with poorer health outcomes for Aboriginal
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14 87 peoples living in remote communities. High reliance on agency nurses is also very likely to be
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16 88 cost-*ineffective*. Investment in a coordinated range of workforce strategies that support
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18 89 recruitment and retention of resident nurses and Aboriginal Health Practitioners in remote clinics
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20 90 is needed to stabilise the workforce, minimise the risks for high staff turnover and overreliance
21
22 91 on agency nurses, and thereby significantly reduce expenditure and improve health outcomes.
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26 92 27 28 93 **Keywords**

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31 94 Remote health, Health workforce, Turnover, Remote area nurse, Aboriginal Health Practitioner,
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33 95 Fly-in fly-out, Remote health services, Health manpower, Indigenous health
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98 **Article Summary**

99 **Strengths and limitations of this study**

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

113 **Introduction**

114 There is an urgent need for high quality primary care (PC) services for disadvantaged Aboriginal
115 and Torres Strait Islander populations (referred to as Aboriginal hereafter) in remote
116 communities of Australia. Australian Aboriginal peoples have higher levels of risk factors for
117 many communicable and non-communicable diseases and experience higher rates of complex
118 acute and chronic diseases such as infectious diseases, ischaemic heart disease, diabetes and
119 chronic kidney disease compared to non-Aboriginal Australians.(1-4) The gaps in life
120 expectancy at birth between Aboriginal and non-Aboriginal population in the Northern Territory
121 (NT) of Australia in 2009-13 were 15 and 16 years in males and females respectively.(5) In
122 2016, 30% of the NT population was Aboriginal and 70% of Aboriginal population lived in rural

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3 123 and remote areas.(6) Australian governments have committed to closing the gap in health
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5 124 outcomes between Aboriginal and non-Aboriginal Australians.(7)
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8 125 In many remote NT communities, PC is mainly delivered by staff employed directly by the NT
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10 126 Government. In these remote communities 'resident' staff comprise, on average, 2 nurses or
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12 127 midwives (henceforth called nurses), 0.6 Aboriginal Health Practitioners (AHPs) and 2.2 other
13
14 128 employees all of whom live in the communities on a medium to long-term basis. Agency-
15
16 129 employed nurses provide, on average, 0.4 FTE of additional health manpower per clinic on a
17
18 130 short-term, fly-in fly-out basis.(8) District medical officers and allied health professionals provide
19
20 131 additional professional services to patients living in these remote communities through
21
22 132 intermittent scheduled visits and telehealth consultations.
23

24
25 133 Recent research shows that higher utilisation of PC services by Aboriginal people with chronic
26
27 134 diseases is cost-effective. Access to, and utilisation of, effective PC, however, may be
28
29 135 compromised in remote NT communities by extremely high turnover rates of resident clinical
30
31 136 staff and heavy reliance on short-term agency nurses.(8-10) Factors previously reported to be
32
33 137 associated with nurse turnover in NT include professional, social and geographical isolation, the
34
35 138 stressful work environment, unreasonably heavy workloads, lack of support from management
36
37 139 and inadequacy of housing.(11) NT Government initiatives in the past decade to decrease nurse
38
39 140 turnover have included changes to management practices to improve levels of support for
40
41 141 nurses, providing increased training and professional development opportunities, increasing the
42
43 142 flexibility of employment contracts and restructuring nursing classifications and increasing
44
45 143 remuneration.(12, 13)
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48
49 144 Primary care costs per person rise as geographical remoteness of communities increases and
50
51 145 population size decreases.(14-16) A large proportion of these costs relates to higher staffing
52
53 146 costs, and costs associated with staff and patients traveling long distances.(14, 17) Workforce
54
55 147 shortages and extremely high staff turnover (averaging 148% per annum for nurses) result in
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2
3 148 42% of NT remote area nurses being employed on relatively expensive casual or agency
4
5 149 contracts.(8, 14, 16, 18)
6
7
8 150 There is a lack of published quantitative evidence, however, of the costs, effectiveness, and
9
10 151 cost-effectiveness of different staffing patterns.(19) The aims of this research, therefore, are
11
12 152 threefold: first, to compare the costs and effects of higher turnover of resident remote area
13
14 153 nurses and AHPs with lower turnover; second, to compare the costs and effects of
15
16 154 proportionally higher use of agency-employed nurses with lower use of agency-employed
17
18 155 nurses; and, third, to quantify the effects of nurse and AHP turnover and use of agency-
19
20 156 employed nurses on health care costs, after adjusting for known confounders.
21
22
23

24 157 **Methods**

26 158 **Study setting**

27
28
29 159 The study sites were 53 NT Department of Health (DOH) remote health clinics in 46
30
31 160 predominantly Aboriginal communities and 7 predominantly non-Aboriginal towns where
32
33 161 resident nurses and AHPs provide most clinical PC services. Temporary and ongoing nursing
34
35 162 and AHP vacancies were filled by DOH employed casual nurses, DOH employed agency
36
37 163 nurses or, as the least preferred, most expensive alternative, by agency-employed nurses
38
39 164 (nurses paid directly by nurse employment agencies). In this study the proportion of agency-
40
41 165 employed nurses was used as a marker of overall use of short-term nurses.
42
43
44

45 166 **Patient involvement**

46
47 167 This study comprised analysis of NT DOH secondary data (including individual-level de-
48
49 168 identified hospitalisation and primary care data). Patients were not directly involved in data
50
51 169 provision.
52
53

54 170 **Data**

1
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
7 173 Payroll Systems (PIPS). The study period was 2013-2015, as this was the most recent period
8
9 174 for which the required costs, hospitalisations, ages at death, use of agency-employed nurses
10
11 175 and workforce turnover data were available.(8)

12
13
14 176 PIPS data were used to calculate turnover rates of Department-employed nurses and AHPs in
15
16 177 each month in each clinic (clinic-month):

17
18
19 178
$$\text{Turnover rate} = \frac{\text{number of exits}}{\text{average number employed}} \times 100$$

20
21
22 179 An exit was defined when a staff member ceased working at a specific remote clinic for a period
23
24 180 of at least 12 weeks. A cut-off of 10% differentiated higher ($\geq 10\%$) from lower ($< 10\%$) turnover,
25
26 181 equating to 120% annual turnover. Previous research showed that the average annual turnover
27
28 182 rate of nurses and AHPs in these remote NT clinics is 128%.(20)

29
30
31 183 GAS data were used to calculate PC costs in Australian dollars for each clinic-month. PC clinic
32
33 184 costs comprised operational and personnel expenditures and excluded capital expenses.
34
35 185 Agency-employed nurse labour expenses were used to derive estimates of aggregated full-time
36
37 186 equivalent (FTE) agency-employed nurse use in each clinic-month using a standard NT DOH
38
39 187 formula:

40
41
42 188
$$\text{Agency-employed nurse FTE} = \frac{\text{Agency-employed nurse labour expenses}}{2 \times \text{average DOH} - \text{employed nurse cost}} \quad (21)$$

43
44
45 189 Percentage use of agency-employed nurses in each clinic-month was calculated:

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47
48 190
$$\text{Percentage of agency-employed nurses} = \frac{\text{Agency-employed nurse FTE}}{\text{Total FTE nurse positions}} \times 100$$

49
50
51 191 A cut-off of 13% differentiated higher ($\geq 13\%$) from lower ($< 13\%$) use of agency-employed
52
53 192 nurses as previous research shows that FTE agency-employed nurses fill, on average, 13% of
54
55 193 nurse positions.(8)

1
2
3 194 PCIS data were used to determine the number of PC consultations in each clinic-month.

4
5 195 Population catchments (service populations) for each remote clinic were defined as the number

6
7 196 of unique patients recorded in PCIS in the previous 12 months.

8
9
10 197 HIA data were used to determine the community in which each patient lived at the time of

11
12 198 hospital admission, to calculate the number of hospitalisations in each clinic-month, and to

13
14 199 estimate hospitalisation costs using information on diagnoses (Australian Refined Diagnosis-

15
16 200 Related Group (DRG) codes) provided in discharge summaries: (22)

17
18 201 Hospitalisation costs = $DRG\ cost\ weight \times NT\ benchmark\ prices$.

19
20
21 202 Both HIA and PCIS data were used to determine age at death, from which Years of Life Lost

22
23 203 (YLLs) were calculated using an age specific life expectancy table used in the Australian Burden

24
25 204 of Disease study.(2)

26
27
28 205 Both GAS and PCIS data were used to estimate PC costs in each clinic-month, calculated by

29
30 206 first deriving an average consultation cost which was the overall estimated expenditure of the

31
32 207 clinic each year divided by the total occasions of service in that year. PC costs per person per

33
34 208 month (person-month) were calculated as the average consultation cost multiplied by the

35
36 209 number of consultations per person-month. Travel costs were calculated by doubling the

37
38 210 straight line distance between the resident community and nearest hospital, based on a flat rate

39
40 211 of \$2 per kilometre.(23)

41 42 43 212 **Analyses**

44
45 213 Two separate incremental cost-effectiveness ratios were calculated using clinic-month data. In

46
47 214 the first analysis (denoted in equations by subscript 1) comparison of costs and effects of higher

48
49 215 turnover clinic-months were compared with lower turnover rates, whereas in the second

50
51 216 analysis (subscript 2) costs and effects of clinic-months with higher use of agency-employed

52
53 217 nurses were compared with lower use of agency-employed nurses.

218 Effects for the respective analyses were calculated as follows:

$$219 \quad \text{Effect rate}_1 = \frac{\text{Total number of hospitalisations}}{\text{Total number of person - months}} \times 1000 ;$$

$$220 \quad \text{Effect rate}_2 = \frac{\text{Total number of YLLs}}{\text{Total number of person - months}} \times 1000 .$$

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

225 Costs for the respective analyses were calculated as follows:

$$226 \quad \text{Costs rate} = \frac{\text{PC} + \text{Travel} + \text{Hospitalisation costs}}{\text{Total number of person - months}} \times 1000.$$

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

$$233 \quad \text{ICER}_1 = \frac{\text{Costs rate in high turnover clinic - months} - \text{Costs rates in lower turnover clinic - months}}{\text{Hospitalisation rate in high turnover clinic - months} - \text{Hospitalisation rate in lower turnover clinic - months}}$$

234 The ICER for the second analysis was calculated as the difference in average health costs per
 235 1000 person-months, divided by the difference in effects (YLLs) per 1000 person-months:

$$236 \quad \text{ICER}_2 = \frac{\text{Costs in higher use of agency employed nurses clinic - months} - \text{Costs in lower use of agency employed nurses clinic - months}}{\text{YLLs rate in higher use of agency employed nurses clinic - months} - \text{YLLs rate in lower use of agency employed nurses clinic - months}}$$

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

1
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3 240 1000 person-months. A 'top down' approach was used to allocate total remote health
4
5 241 expenditure to each clinic, as described elsewhere. All costs were based on actual expenditure.
6
7
8 242 In addition to calculating ICER point estimates, 2000 Bootstrap replicates were used to plot
9
10 243 cost-effectiveness planes (mean differences in the cost and effect pairs) and to construct cost-
11
12 244 effectiveness acceptability curves (probability that lower turnover or lower proportional use of
13
14 245 agency-employed nurses is cost-effective) to investigate uncertainty. Calculations of ICER also
15
16 246 examined variations in costs and effects if:

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18
19 247 (1) clinics servicing predominantly non-Aboriginal communities were excluded;

20
21 248 (2) hospitalisations for renal dialysis were excluded; and

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23
24 249 (3) only potentially preventable hospitalisations (PPH) were included.(24)

25
26
27 250 The average NT cost per hospitalisation of \$4,213 was used as the benchmark price for a
28
29 251 hospitalisation.(22) A threshold of \$120,000 was used as the benchmark price for a YLL.(25)

30
31 252 Multiple regression was used to investigate associations between overall costs and nurse and
32
33 253 AHP turnover rates and proportional use of agency-employed nurses, after adjusting for key
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35 254 confounders. Potential confounders included Euclidean distance to the nearest hospital, PC
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37 255 consultation rates, and hospitalisation rates (both total and PPH).

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40 256 StataSE v14 was used for all analyses. A 0.05 level of statistical significance was used.

41 42 43 257 **Ethics**

44
45 258 Ethics approval was received from the Human Research Ethics Committee of the NT DOH and
46
47 259 Menzies School of Health Research (2015-2363).

260 Results

261 Between 2013 and 2015 there were 1,266,708 person-months, 46,276 hospital admissions,
 262 2,058,829 PC consultations, and a service population of approximately 35,000 persons. Total
 263 health costs were \$603 million and there were 530 deaths with an estimated 17,750 YLLs.

264 1. Higher versus lower turnover

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

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

277 **Table 1. Average health costs, hospitalisations, and incremental cost-effectiveness ratio**
 278 **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 ($\geq 10\%$)	229,968	193,328	229,968	229,968
	Lower ($< 10\%$)	1,036,740	878,406	1,036,740	1,036,740
Hospitalisations (per 1000 person-months)	Higher ($\geq 10\%$)	45.3	51.7	17.8	2.5
	Lower ($< 10\%$)	34.6	38.4	16.0	2.4
	<i>p</i> -value	< 0.001	< 0.001	< 0.001	0.430
Average health cost (\$) (per 1000 person-	Higher ($\geq 10\%$)	\$491,043	\$531,865	\$446,344	\$289,741
months)	Lower ($< 10\%$)	\$472,826	\$511,977	\$440,355	\$300,740

months)	<i>p</i> -value	0.002	0.003	0.271	<0.001
Incremental cost-effectiveness ratio		\$1,708	\$1,500	\$3,365	-\$107,830

279

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

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

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

295 **Table 2. Average health costs, years of life lost, and incremental cost-effectiveness ratio**
 296 **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 ($\geq 13\%$)	704,240	636,525	704,240	704,240
	Lower ($<13\%$)	562,468	435,209	562,468	562,468
YLL (per 1000 person-months)	Higher ($\geq 13\%$)	14.6	13.7	14.6	0.0
	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-months)	Higher ($\geq 13\%$)	\$480,915	\$503,989	\$446,289	\$301,567
	Lower ($<13\%$)	\$470,145	\$532,494	\$435,375	\$295,207

	<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 rates

299 Overall health cost rates were significantly associated with hospitalisations, PPHs, PC

300 consultations, turnover, use of agency-employed nurses, and distance to nearest hospital.

301 (Table 3) Each 10% increase in annual turnover was associated with an increased cost of \$11

302 per person-month. For each 10% increase in proportion of agency-employed nurses used, there

303 was an associated increase in cost of \$10 per person-month. One PPH was associated with an

304 increased cost of \$10,063, which was in addition to the costs of a normal hospitalisation.

305 Sensitivity analyses (not shown) revealed similar coefficient estimates.

306 Assuming a service population of 35,000 residents, reducing turnover from 120% per annum to

307 60% and no longer using agency-employed nurses (reducing from 13% to 0%) results in

308 potential savings of \$32 million annually in PC, hospitalisations, and travel costs.

309

310 **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

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

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5 313 **Discussion**

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8 314 This landmark empirical study shows that lower nurse and AHP turnover is associated with
9
10 315 significantly lower total hospitalisations ($p<0.001$), lower average health cost rates ($p=0.002$)
11
12 316 and is more cost-effective than higher turnover. The potential savings in health care costs of
13
14 317 reducing staff turnover are in the order of \$32 million annually. Also, lower use of short-term
15
16 318 agency nurses has an 84% likelihood of being more cost-effective than higher use.

17
18
19 319 For Aboriginal communities, PC cost rates were significantly higher in clinic-months that had
20
21 320 lower use of agency-employed nurses. This finding was, at face value, counter-intuitive, as
22
23 321 agency-employed labour hire is the most expensive staffing option. One possible explanation is
24
25 322 confounding of the association by geographical remoteness: the multiple linear regression
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27 323 analysis confirmed that more geographically remote clinics have higher operating costs,
28
29 324 consistent with previous research.⁽¹⁴⁾ More geographically remote clinics may also be more
30
31 325 likely to have lower use of agency nurses and incur even higher costs, for example because
32
33 326 agency-employed nurses may be less willing to work in the most geographically remote health
34
35 327 services. This research used regression analysis to confirm that health care costs in remote PC
36
37 328 clinics are positively and significantly associated with hospitalisations (total and PPH), nurse
38
39 329 and AHP turnover rates, use of agency-employed nurses, geographical remoteness and the
40
41 330 number of primary care consultations (Table 3).

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44
45 331 These are important findings for policymakers and health service managers. The findings
46
47 332 suggest that effective investments in workforce strategies that reduce turnover rates and
48
49 333 decrease undue reliance on short-term agency nurses may have very significant net benefits,
50
51 334 both to the health services' budgets as well as to longer term health outcomes for
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53 335 disadvantaged Aboriginal populations.

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3 336 This research highlights a pressing need to invest in the systematic implementation of a co-
4
5 337 ordinated range of short and longer term remote workforce strategies in order to stabilise the
6
7 338 workforce, improve continuity of care, and thereby improve health outcomes. Whilst our
8
9 339 knowledge about the effectiveness of various PC workforce retention interventions is incomplete
10
11 340 (26), available evidence suggests that effective short-term retention strategies should be
12
13 341 multifaceted and include the following components: necessary infrastructure, including adequate
14
15 342 housing, vehicle, and communication technologies; offer realistic remuneration, including salary
16
17 343 packaging and retention bonuses; ensure organisational effectiveness by (i) strengthening
18
19 344 health service and clinic management and leadership, (ii) ensuring comprehensive staff
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21 345 orientation and induction, and (iii) maintaining a professional environment through mentoring,
22
23 346 ongoing professional development, and promoting scholarship; provide appropriate personal
24
25 347 and family support for employees; and implement alternative workforce models that are more
26
27 348 likely to ensure continuity of care, such as employing nurses to work one month on, one month
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29 349 off in shared positions.

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32
33 350 Longer-term retention strategies, similarly, may best be bundled together, and may include:
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35 351 providing sufficient funding to ensure an adequate supply of remote health professionals
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37 352 relative to population needs without undue reliance on short-term staff; increased recruitment of,
38
39 353 and support for, Aboriginal people to take up clinical and non-clinical roles, which may include
40
41 354 the adoption of training models which enable AHP training to be largely based in remote
42
43 355 communities; building appropriate training pathways for remote area nurses in partnership with
44
45 356 local educational institutions, with a particular focus on appropriate student selection, a
46
47 357 contextualised program, and a supported post-graduate employment pathway; and transitioning
48
49 358 governance arrangements from NT Government-run to Aboriginal community control. While it is
50
51 359 not known whether community-control of health services is associated with lower health
52
53 360 workforce turnover and lower use of short-term agency nurses, we do know that Aboriginal
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3 361 Community Controlled Health Services employ a high proportion of Aboriginal staff, and that
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5 362 family connections and a sense of ownership of the service (27) contribute to improved access.
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7 363 (28, 29)
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9

10 364 This study is not without some limitations. Firstly, estimates of the effects of PC used proxy
11
12 365 measures – total hospitalisations and YLL – which may not necessarily best reflect
13
14 366 effectiveness of PC. While our analyses extended to investigate variability in results if only
15
16 367 PPHs were included, these too have limitations in the context of this study. PPHs comprise <8%
17
18 368 of total hospitalisations and the communities in this study were mostly small, so monthly PPHs
19
20 369 rates in each remote community have the limitation of increased statistical instability, which may
21
22 370 explain the unexpected association between higher proportional use of agency-employed
23
24 371 nurses and lower costs. Secondly, comparison groups for costs and effects were somewhat
25
26 372 arbitrarily defined based on clinic-month rather than individual level data. It would have been
27
28 373 preferable to make comparisons on the basis of use of all agency nurses, not just of agency-
29
30 374 employed nurses. However, we were not able to accurately identify DOH-employed agency
31
32 375 nurses within the payroll data. Also, there were a small number of non-Aboriginal residents in
33
34 376 remote Aboriginal communities. Because the non-Aboriginal residents were predominantly
35
36 377 healthy workers, the impacts of non-Aboriginal residents on clinic-month health measures were
37
38 378 expected to be minimal. Thirdly, our cost estimates may also be imprecise, as they are
39
40 379 dependent on the quality of administrative data on expenditure recorded in GAS and on
41
42 380 consultation data recorded in PCIS. Fourthly, our study also did not include effects of any policy
43
44 381 measures designed to reduce staff turnover, nor did it attempt to measure the costs of
45
46 382 introducing such policies. While the findings of our study are likely generalisable to other
47
48 383 primary care clinics in remote, predominantly Aboriginal communities in Australia, caution is
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50 384 advised in generalising beyond these limits. This is an observational study comparing two
51
52 385 different situations (higher vs lower turnover; higher vs lower proportional use of agency-
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3 386 employed nurses) using existing administrative data. It is indicative of two simple workforce
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5 387 policy scenarios in which cost-effectiveness information is otherwise lacking. No evidence
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7 388 synthesis and decision modelling were undertaken in this study.
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10 389 Despite its limitations, the findings of this research provide critically important evidence for
11
12 390 policymakers seeking to improve health outcomes for Aboriginal people living in remote
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14 391 Australia while responsibly managing finite health budgets. There is great potential for more
15
16 392 cost-effective PC to be attained. This will require PC workforce turnover, retention, and use of
17
18 393 short-term agency-employed nurses to be addressed as a priority.
19
20

21 394 **Conclusion**

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23
24 395 Higher turnover of government-employed nurses and AHPs is costly and associated with poorer
25
26 396 health outcomes for Aboriginal people. Halving the current annual turnover rate to 60% and
27
28 397 reducing use of agency-employed nurses has the potential to reduce costs to the NT health
29
30 398 system by \$32 million each year. Systemic investment in a range of co-ordinated workforce
31
32 399 strategies is needed to stabilise the remote workforce, save money, improve Aboriginal health
33
34 400 outcomes and 'close the gap'.
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38 401

40 402 **List of Abbreviations**

41 403	AHPs	Aboriginal Health Practitioners
42 404	DOH	Department of Health
43 405	DRG	Diagnosis-Related Group
44 406	FTE	Full-time Equivalent
45 407	GAS	Government Accounting System

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3	408	HIA	Hospital Inpatients Activity
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6	409	ICER	Incremental Cost-Effectiveness Ratio
7			
8	410	NT	Northern Territory
9			
10			
11	411	PC	Primary Care
12			
13			
14	412	PCIS	Primary Care Information Systems
15			
16	413	PIPS	Personnel Information and Payroll Systems
17			
18			
19	414	PPH	Potentially Preventable Hospitalisation
20			
21	415	YLL	Year of Life Lost
22			
23			
24	416		
25			

417 **Declarations**

418 **Ethics approval**

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

421 **Original protocol for the study**

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

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

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429 reporting of this analysis.

430 **Competing interests**

1
2
3 431 The authors declare that they have no competing interests.
4

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6 432 **Data sharing statement**

7 433 The datasets generated and analysed during the current study are not publicly available due to
8
9 434 identifiability of remote primary care providers and the need to protect their privacy.
10

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12 435

13
14 436 **Author contributions**

15
16 437 YZ contributed to the design of the study and led analysis and drafting of the paper. JW
17
18 438 conceived and contributed to design of the overarching study and assisted with drafting the
19
20 439 paper. JSH contributed to the conceptualization and design of the study and assisted with
21
22 440 drafting the manuscript. MPJ, SG, MR and DJR contributed to the design of the study,
23
24 441 particularly the quantitative component, and provided comments on the manuscript. All authors
25
26 442 read and approved the final manuscript.
27
28

29
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40
41 449 Gold, Tim Carey and David Lyle to the bigger overarching research project and for comments
42
43 450 that strengthened this manuscript.
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4**Figure Titles**5
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9 531 **Figure 1. Cost-effectiveness plane comparing higher ($\geq 10\%$) with lower ($< 10\%$) monthly**
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11 532 **turnover rates in remote clinics**

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15 534 **Figure 2. Cost-effectiveness acceptability curve for comparing costs and effects in**
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17 535 **savings in total health costs between higher ($\geq 10\%$) and lower ($< 10\%$) monthly nurse and**
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19 536 **Aboriginal Health Practitioner turnover rates in remote clinics**

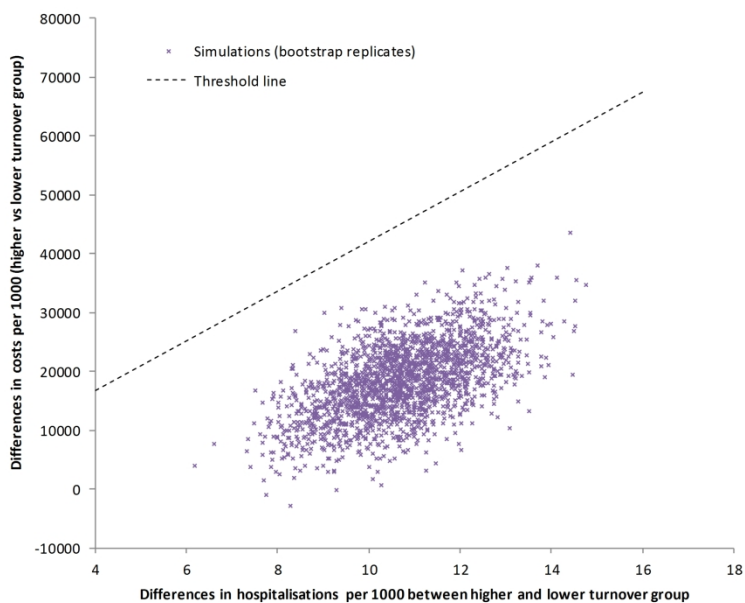
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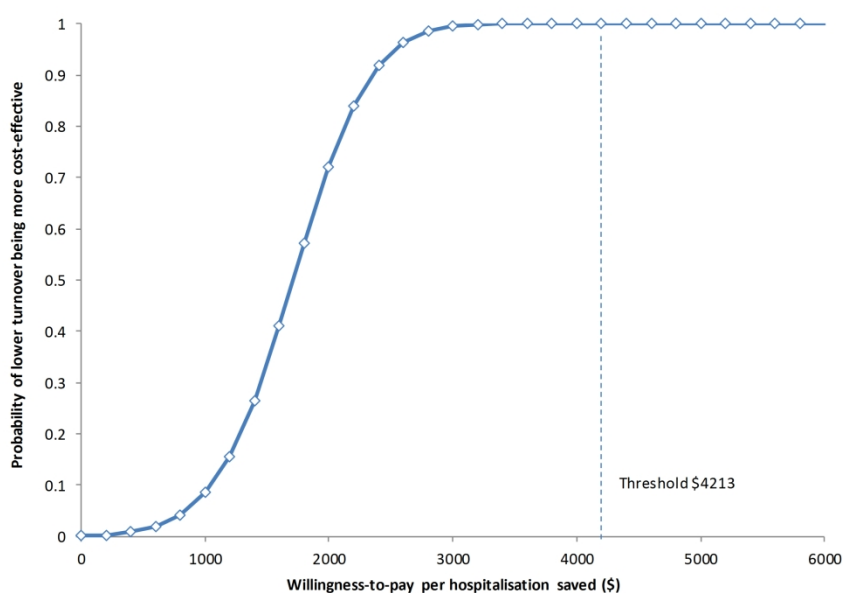
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31 541 **Figure 4. Acceptability curve for comparing costs and effects in terms of saving life-**
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33 542 **years between higher ($\geq 10\%$) and lower ($< 10\%$) proportional use of agency nurses in**
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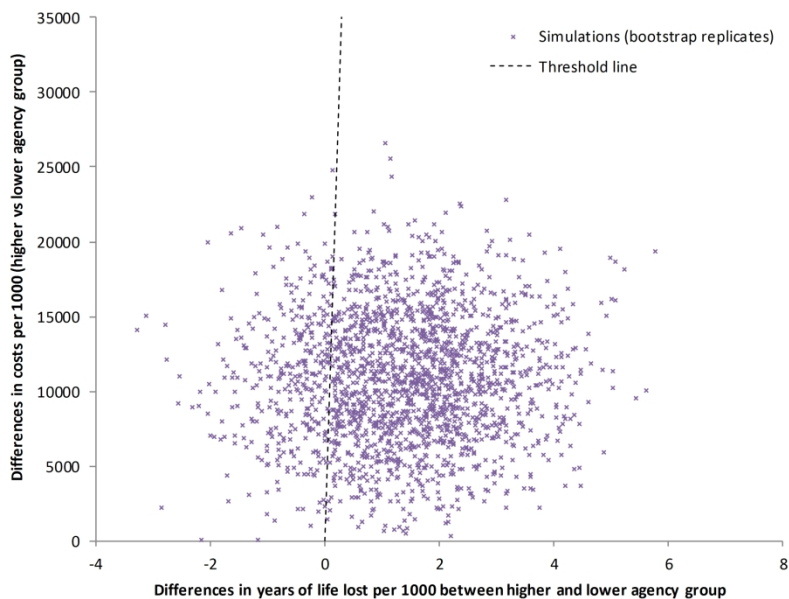


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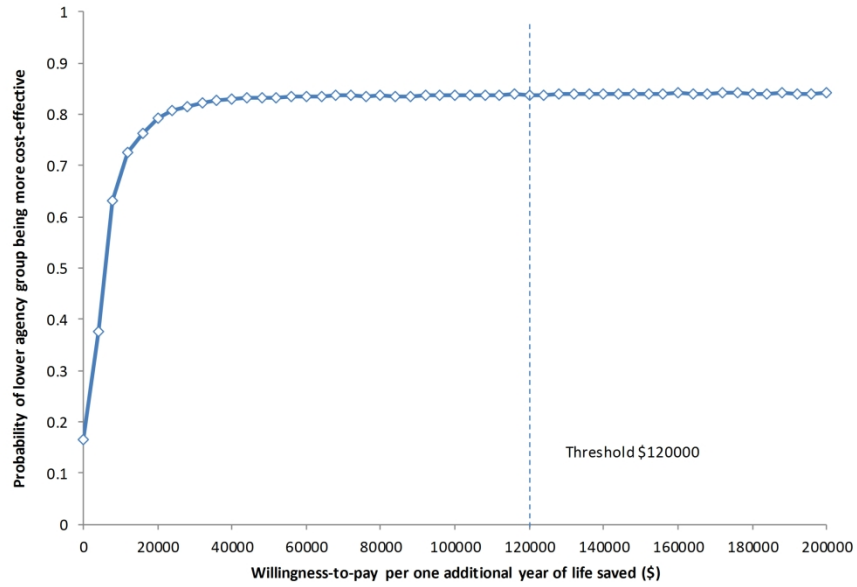


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CHEERS checklist—Items to include when reporting economic evaluations of health interventions

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	<i>Single study-based estimates</i> : 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	<i>Synthesis-based estimates</i> : 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	<i>Single study-based economic evaluation</i> : 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	<i>Model-based economic evaluation:</i> 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	<i>Single study-based economic evaluation:</i> 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	<i>Model-based economic evaluation:</i> 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