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Effects of turnover and stability of health staff on quality of care in remote communities of the Northern Territory, Australia: a retrospective cohort study

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Complete List of Authors:	Jones, Michael; Macquarie University Zhao, Yuejen; Northern Territory Department of Health, Population and Digital Health Guthridge, Steven; Menzies School of Health Research, Charles Darwin University Russell, Deborah; Menzies School of Health Research Alice Springs Office, Charles Darwin University Ramjan, Mark; Northern Territory Department of Health, Clinical Governance, Darwin Region & Strategic Primary Health Care Humphreys, John; Monash University, School of Rural Health Wakerman, John ; Menzies School of Health Research Alice Springs Office, Charles Darwin University
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10 Authors: Michael P Jones,¹ Yuejen Zhao,² Steven Guthridge,³ Deborah Jane Russell,⁴ Mark
11
12 Ramjan,⁵ John S Humphreys,⁶ John Wakerman⁴
13
14
15
16
17

18 Author affiliations
19

20 ¹Faculty of Human Sciences, Macquarie University, Sydney, New South Wales,
21
22 Australia
23

24 ²NT Department of Health, Innovation and Research, Darwin, Northern Territory,
25
26 Australia
27

28 ³Menzies School of Health Research, Charles Darwin University, Casuarina, Northern
29
30 Territory, Australia
31
32

33 ⁴Menzies School of Health Research, Charles Darwin University, Alice Springs, Northern
34
35 Territory, Australia
36
37

38 ⁵Population and Primary Health Care, Top End Health Services, NT Department of Health,
39
40 Darwin, NT, Australia
41
42

43 ⁶Monash Rural Health, Monash University, Bendigo, Victoria, Australia
44
45
46
47
48
49
50
51

52 Corresponding author:
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54
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56 Prof Michael P. Jones
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58 Psychology Department
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Macquarie University
North Ryde NSW 2109
Australia

fax: n/a

email: mike.jones@mq.edu.au

For peer review only

1
2
3 Abstract
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8 **Objectives** To evaluate the relationship between markers of staff employment stability and
9
10 use of short-term health care workers with markers of quality of care.
11

12 **Design** Retrospective cohort.
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14 **Setting** Northern Territory Government primary health care clinics in remote communities.
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17 **Outcome Measures** Resident Remote Area Nurse (RAN) and Aboriginal Health Practitioner
18 (AHP) turnover rates, stability rates and the proportional use of agency nurses.
19
20

21 **Results** The proportion of resident Aboriginal clients receiving high quality care as measured
22 by various quality indicators varied considerably across indicators and clinics. Higher quality
23 care was more likely to be received for management of chronic diseases such as diabetes
24 and least likely to be received for general/preventive adult health checks. Many indicators
25 had target goals of 0.80 which were mostly not achieved. The evidence for associations
26 between decreased stability measures or increased use of agency nurses and reduced
27 achievement of quality indicators was not as clearly supported as hypothesised. For the
28 majority of associations, the overall effect sizes were small (close to zero) and failed to
29 reach statistical significance. Where statistically significant associations were found, they
30 were generally in the hypothesised direction.
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46 **Conclusions** Two clear findings emerge from this study. One is that lower staff stability and
47 greater use of short-term health workforce is associated with deficits in quality of care for
48 some clinics but not for others. Understanding the reasons for this variation would
49 significantly aid the provision of clinical care in remote Australia. The second is that the data
50 needed to understand this important question of quality of care are challenging to obtain.
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3 The public interest would be served by the development of health information systems that
4
5 better facilitate analyses such as those undertaken here.
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10 **Strengths and limitations of this study**

- 13 • Data are for an entire population—remote living residents in communities serviced
14 by Northern Territory Department of Health;
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- 17 • Analyses adjusted for key potential confounders;
18
- 20 • The major limitation was the retrospective design, relying on routinely collected and
21 administrative data.
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INTRODUCTION

Australia is a geographically large country (7.7 million square kilometres) with a concentration of both population and health care resources along its eastern and southern seaboard.¹ In 2019, 69% of the Australian estimated resident population lived in the eastern and southern seaboard State capital cities and three large regional towns (Newcastle, Wollongong and Geelong)². A relatively small fraction of the Australia's health care resources are used to service the primary health care (PHC) needs of its extensive rural and remote populations, with the National Rural Health Alliance estimating a large rural health expenditure deficit of approximately \$2bn per annum.³

In non-metropolitan Australia, access to PHC is further limited by the combination of high health need and the need for cultural competency when providing health services for Australian Aboriginal and Torres Strait Islander populations who have much greater health needs across both acute and chronic conditions relative to all Australians.⁴ This is particularly apparent in the Aboriginal population of the Northern Territory (NT) where chronic diseases such as cardiovascular disease and diabetes are up to four times more prevalent and life expectancy at birth is approximately 16 years less than the corresponding measure for Australia as a whole.⁵ While continuity of care is important for all patients, it is especially important for vulnerable populations, such as Aboriginal and Torres Strait Islander populations living in small, isolated communities.^{6,7} Continuity of high quality PHC can help ensure chronic health conditions are prevented where possible, and diagnosed early and managed optimally where not, ensuring that patients avoid potentially preventable hospitalisations.^{8,9}

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3 The long-standing geographical maldistribution of general practitioners (GPs) has been the
4 target of numerous programs by government and health professional bodies over a long
5
6 target of numerous programs by government and health professional bodies over a long
7
8 period, with only mixed success.¹⁰⁻¹² In geographically remote areas, PHC services are more
9
10 commonly provided by resident Remote Area Nurses (RANs) and Aboriginal Health
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12 Practitioners (AHPs), supported by visiting medical, nursing and allied health professionals,
13
14 and other short-term health workers engaged on a fly-in fly-out or drive-in-drive-out basis
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16 and often engaged through employment agencies.¹³ While resident staff remain in a
17
18 community from months to several years and therefore get to know and be known by
19
20 community members, short-term employment agency staff may only be in a community for
21
22 a period of weeks. Such short tenure makes continuity of care less attainable and staff less
23
24 able to develop appropriate levels of cultural and social awareness to engage effectively
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26 with local residents, leading to lower utilisation of PHC services.^{14,15} Lower PHC utilisation
27
28 may contribute to poorer health outcomes: better access and utilisation of PHC by
29
30 Aboriginal people living in remote NT communities and remote outstations is associated
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32 with lower mortality, lower morbidity and more cost-effective health care, though the
33
34 association between PHC utilisation and hospitalisations is more complex.¹⁶⁻¹⁸
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42 A further potential consequence of poor continuity of care and cultural attunement of
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44 health care staff is reduced quality of care. Short-term staff may focus on acute care needs
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46 and neglect or have insufficient awareness of preventive and chronic care needs, such as
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48 health promotion, health screening, monitoring chronic health conditions, encouraging
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50 smoking cessation or checking the immunisation status of infants and adults. Most, though
51
52 not all, research shows that continuity of PHC provider is associated with better control of
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54 type 2 diabetes¹⁹⁻²² as well as increased provision of preventive care services including
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56 immunisations and screening for hypertension, alcohol abuse and high cholesterol levels.²³
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3 However, the extent to which continuity of care and measures of staff turnover and stability
4
5 are associated with quality of care in complex cross-cultural contexts characterised by
6
7 reliance on short-term PHC providers is not well-understood. While research using a case
8
9 study design suggests that in remote NT, PHC workforce turnover is the most significant
10
11 barrier to successful quality improvement, the association between workforce turnover or
12
13 stability and quality of PHC in remote NT is yet to be verified using stronger study designs.²⁴
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18 This article therefore seeks to evaluate the relationship between markers of staff
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20 employment stability and turnover and use of short-term PHC staff with markers of quality
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22 of care, in order to determine whether these are detrimental to the care received by
23
24 residents of remote locations. We hypothesised that stability would be positively associated
25
26 with quality measures and that turnover and the use of short-term PHC staff would be
27
28 negatively associated with quality measures. We also sought to identify factors which may
29
30 counter hypothesised reduced quality of care caused by lower stability, higher turnover or
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32 higher use of short-term staff.
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41 **METHODS**

42 43 44 45 46 Study design and setting

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50 This observational study has a retrospective cohort design: the cohort consists of patients,
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52 RANs, AHPs and short-term staff of 48 NT Department of Health (DoH) remote clinics during
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54 the period 2011-2015, inclusive.
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Data

Data were provided by the NT DoH. Workforce data were obtained from the Personnel Information and Payroll Systems (PIPS) dataset. PIPS data provided comprehensive, individual-level, de-identified information on all RANs and AHPs paid directly through the NT DoH payroll. These data were used to ascertain the number of RAN and AHP exits from remote health services and to calculate annual turnover and 12-month stability rates. The Government Accounting System (GAS) was used to identify labour hire costs for agency nurses paid directly by employment agencies (hereafter termed agency nurses). The aggregated full-time equivalent (FTE) for agency-employed nurses working in remote health services was derived using the standard NT DoH formula of agency labour expenses divided by twice the departmental annual average nurse personnel cost.²⁵

Quarterly Traffic Light Reports were produced by NT DoH staff for each remote community as part of the Chronic Conditions Management Model.²⁶ The combined Traffic Light Report, which has retrospective data for all NT DoH remote health clinics, was the source of data for twelve quality indicators. Data for some indicators were available every 3 months from March 2012 through to November 2015, though reporting on other indicators commenced at a later date (the latest being August 2013). Additionally, routine health services reports of NT Aboriginal Health Key Performance Indicators (AHKPIs) were the source of data for a further twelve quality indicators. NT AHKPI data were available for 48 of 53 NT DoH clinics in the larger study. NT AHKPI data were not available for five clinics that used a different PHC electronic clinical records management system.

Measures

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3 In this study the main independent variables were clinic-level measures of RAN and AHP
4 annual turnover and 12-month stability, and the proportional use of agency nurses.
5
6 Hereafter, these three measures will be collectively referred to as markers of staff
7
8 employment stability. We used three different measures of staff employment stability
9
10 because of the complexities involved in staffing remote health services, the known heavy
11
12 reliance on agency nurses in remote NT and because none of these workforce metrics on
13
14 their own provide a sufficiently comprehensive picture of workforce mobility patterns.^{27,28}
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16 The three main workforce metrics are defined in Table 1. An additional metric, the number
17
18 of exits from a health service (which is the numerator of the turnover metric), was used in
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20 the Latent Class Analysis.
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[Table 1 about here]

33 Additional independent variables included remote community population size, average
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35 number of employees, Euclidean distance in kilometres to the major centres of Darwin or
36
37 Alice Springs (whichever was closest) and Euclidean distance in kilometres to the nearest of
38
39 the five NT hospitals (distances calculated using google maps). The socioeconomic status of
40
41 the community in which each clinic was located was measured using the Index of Relative
42
43 Socio-economic Advantage and Disadvantage (IRSAD) for clinic catchment
44
45 areas' average scores for Indigenous localities (ILOC)²⁹ as measured in the 2011 national
46
47 census conducted by the Australian Bureau of Statistics (ABS). The Aboriginal composition of
48
49 each community was measured as the proportion of the resident population identifying as
50
51 an Aboriginal person in the 2016 census.³⁰ The latter was dichotomised into whether or not
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53 Aboriginal people comprised a majority of the population (>50%) in the community.
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3 We were initially provided with data for 24 quality indicators (several of which were the
4 same indicator but measured using different data sources at slightly different time points).
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6 Some indicators also had more than one component. For example, child immunisation was
7
8 categorised into different age groups and glycated haemoglobin (HbA1c) results were
9
10 categorised into different levels of glycaemic control. Our aim was to examine a sufficient
11
12 range of indicators of quality of care to ensure that a reasonable spectrum of PHC activities
13
14 was covered by the indicators, rather than to be exhaustive. We therefore grouped quality
15
16 indicators into three categories: child and maternal health; chronic disease management;
17
18 and preventive health activity, and reduced the number of indicators, ensuring there were
19
20 at least three indicators within each category. (Table 2) The reporting period for the
21
22 indicators ranged from six months for the HbA1c test reported in the NT AHKPIs, up to two
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24 years.
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32 [Insert Table 2 about here]
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38 **Statistical approach**

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40 The associations between markers of staff employment stability (independent variables, IV)
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42 and markers of quality (dependent variables, DV) were assessed using linear regression
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44 which employed the linearisation method³¹ to estimate the within-clinic correlation and
45
46 adjust standard errors accordingly. Each DV was expressed as the sequential change from
47
48 the previous period (month, quarter or half year) to express change in indicator status. Due
49
50 to the non-Normal distribution of some outcome variables, formal statistical inference
51
52 employed the nonparametric bootstrap method. The direction and strength of the
53
54 associations between IVs and DVs is reported through the regression slopes (β coefficients)
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56 along with 95% confidence interval upper and lower limits and two-tailed p-values.
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3 Clinic-specific estimates of the associations between IVs and DVs were also calculated using
4
5 linear regression and the standard deviation of coefficients is reported as a measure of
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7 between-clinic variation in the influence of markers of staff employment stability on quality
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9 of care.
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13 Considerable between-clinic heterogeneity was identified. To aid in understanding clinic
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15 profiles that are associated with stronger or weaker associations, clinics were clustered into
16
17 mutually exclusive groups based on their markers of staff employment stability using latent
18
19 class models.³² Variation between clusters of clinics with respect to association (slopes)
20
21 between markers of staff employment stability and quality measures were examined to
22
23 generate hypotheses concerning clinic factors that might counter the effects of reduced
24
25 staffing stability or increased turnover or use of agency nurses. The clustering process can
26
27 be hindered by multivariate outliers that have undue influence on the cluster solution.^{33,34}
28
29 For this reason a two-cluster solution was set as a first step in which forty-four clinics were
30
31 allocated to one cluster and just four into the second. The analysis was then repeated on
32
33 the forty-four remaining clinics. The four clinics omitted from this analysis yielded
34
35 statistically significantly lower stability scores ($p=0.04$), higher turnover ($p=0.002$) and lower
36
37 proportional use of agency nurses ($p=0.004$). Quality-of-care measures for the four clinics
38
39 that were omitted from the modelling as multivariate outliers were also compared with the
40
41 clinics included in the analysis. Given the very small number of clinics omitted it is difficult
42
43 to make any firm conclusions, and no differences reached statistical significance, but there
44
45 was a general trend for these clinics to have lower rates of meeting quality criteria.
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54 55 **RESULTS** 56 57 58 59 60

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3 Included clinics were relatively small with respect to staffing (Table 3) and located distant
4
5 from the major NT centres of Darwin and Alice Springs, on average 304 kilometres (SD=191)
6
7 from the nearest of these. The average clinic had 4-5 staff at any point in time although
8
9 there was considerable variation between clinics with some having less than one and others
10
11 almost twenty. Similarly, there was considerable between-clinic variation in the measures of
12
13 turnover, stability and use of short-term staff, with some clinics having mean scores
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15 approximately twice the overall average. Agency nurses made up a little under 20% of
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17 remote staff, on average, although these values also varied considerably between clinics
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19 with the highest being over 40%.
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26 [Insert Table 3 about here]
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32 The proportion of resident Aboriginal clients receiving high quality care as measured by the
33
34 various quality indicators varied considerably across indicators and clinics (with some
35
36 variation also evident by dataset). On average, high quality care was more likely to be
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38 received for management of chronic disease such as diabetes and least likely to be received
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40 for general/preventive adult health checks. Many indicators used in the Traffic Light Report
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42 program had target goals of 0.80. These target goals were mostly not achieved.
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49 [Insert Table 4 about here]
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55 The evidence for associations between markers of staff employment stability and reduced
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57 performance as measured by markers of quality was not as clearly supported as
58
59 hypothesised. For the majority of associations reported in Table 4 the overall effect sizes
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3 (slopes) were small (close to zero) and failed to reach statistical significance. Where
4
5 statistically significant associations were found, however, they were generally in the
6
7 hypothesised direction. Examples include increased turnover being associated with lower
8
9 proportions of eligible women having pap smears within the previous five years and lower
10
11 proportions of children being fully immunised (6-11 months); and increased stability
12
13 associated with glycaemic control ($HbA1c \leq 8\%$). There are however exceptions, such as
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15 where increased turnover was associated with higher achievement of adult 55+ health
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17 checks.
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[Insert Figure 1 about here]

28
29 A common finding was considerable between-clinic variation in markers of staff
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31 employment stability and quality indicators, although the degree of variation between
32
33 clinics was inconsistent and differed with different levels of a quality indicator. Figure 1
34
35 illustrates this for the association between proportion of agency nurse and three levels of
36
37 provision of antenatal care where the median slope is close to zero for all three levels of the
38
39 antenatal care indicator. During the first and second trimester, the association with
40
41 proportion of agency nurses appears to vary widely between positive and negative values
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43 while for receiving care at any time before the end of pregnancy there is relatively little
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45 between-clinic variation. Hence the overall association effect size can hide considerable
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47 variation in the direction and magnitude of association in individual clinics.
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[Insert Table 5 about here]

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3 Subsequent to finding the considerable variation between clinics described above, latent
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5 class analysis was undertaken which identified three clusters of clinics (columns labelled 1, 2
6
7 and 3 in Table 5) which appear to represent a gradient in the markers of staff employment
8
9 stability. Cluster 1 is distinguished by a comparatively high mean number of staff exits but
10
11 also high variance in staff exits over time. This cluster has levels of average stability and
12
13 turnover that are in between those of Clusters 2 and 3. The second cluster has relatively
14
15 lower average and variance in staff exits, lower turnover and higher stability scores, hence
16
17 represents a hypothetically desirable group of clinics on average. The third cluster lies
18
19 between the first and second with lower mean and variance over time in staff exits than
20
21 Cluster 1 but has the highest turnover (indicative of smaller clinic size than Cluster 1 clinics),
22
23 the lowest stability and the highest proportional use of agency nurses, hence represents a
24
25 hypothetically undesirable group of clinics on average. There was overall less variation in
26
27 the mean proportion of agency nurses between clusters, with Cluster 2 having the lowest
28
29 proportion (17%) and Cluster 3 the highest (20%).
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40 [Insert Table 6 about here]
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46 In general, there was not clinically meaningful and statistically significant variance in quality
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48 indicator achievement between clusters (Table 6). Exceptions were lower use of Angiotensin
49
50 Converting Enzyme Inhibitor) and/or Angiotensin Receptor Blocker in Cluster 1 than Clusters
51
52 2 and 3 and higher rates of childhood anaemia in clinics in cluster 1 than in Clusters 2 and 3.
53
54 However in general the clusters are not differentiated with respect to indicators of quality
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56 of care.
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3 [Insert Table 7 about here]
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8 Table 7 presents the mean association effect sizes across clusters according to the markers of staff
9 employment stability and quality indicator combinations. In general clusters did not differ
10 substantially or in a statistically significantly way with respect to strength/direction of the
11 association. Exceptions included the association between stability and antenatal care at any time
12 during pregnancy for which Cluster 2 reported more negative association; and pap smears at two
13 years, for which Cluster 1 reported a positive association with stability whereas the other clusters
14 reported no association.
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27 **DISCUSSION**

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32 Overall, minimal evidence of the hypothesised negative effects of increased turnover,
33 decreased stability and increased reliance on temporary staff on quality of care was found.
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35 In a small number of cases there were statistically significant associations in the
36 hypothesised direction, a smaller number in a direction opposite to that hypothesised, but
37 the majority yielded overall association measures (slopes) that were close to zero and failed
38 to reach statistical significance (Table 2). While these findings could indicate that the
39 hypothesised negative effects on quality of care are not supported by the evidence, there
40 are several pointers that on-the-ground reality might not be that simple. First, while the
41 overall estimates of association were all close to zero, there was substantial variation in the
42 clinic-specific estimates, meaning that in some clinics quality was negatively associated with
43 higher turnover, lower stability and lower use of short-term staff but in other clinics quality
44 was unrelated or even positively related with these measures. The latter, counter-
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3 hypothesised results might reflect random chance but they might also reflect clinic-specific
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5 factors that counter the potential negative effects of decreased workforce stability,
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7 increased turnover and increased use of short-term staff. A clustering of clinics based on
8
9 markers of staff employment stability failed to yield clinic groupings that explain the
10
11 between-clinic variation in associations (Table 7).
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16 Alternate explanations of this variability might include a number of unquantified local
17
18 factors. For example, a competent clinic manager may be able to manage an unstable
19
20 workforce more effectively, thus mitigating the deficits that might otherwise have
21
22 occurred.³⁵ A robust Continual Quality Improvement program, visiting outreach health
23
24 staff, and clinic-level data reports may also counter any negative effects of employment
25
26 instability. Heavy reliance on short-term agency nurses might not be as detrimental as
27
28 hypothesised if some of these nurses return repeatedly to the same clinic or group of clinics,
29
30 and thus have local knowledge and long-standing relationships with residents which
31
32 facilitate continuity of care.³⁶ Or it may be that in some instances skilled agency nurses
33
34 enable resident RANs to take planned annual leave or undertake professional development,
35
36 rather than having a stream of inexperienced or poorly prepared agency nurses filling
37
38 longstanding vacancies at short notice.³⁵ In these ways, the administrative data might
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40 indicate greater instability in the workforce than is actually experienced in terms of
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42 continuity of care on the ground.
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50 Other factors that cannot be readily quantified that may contribute to the observed
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52 variability include both the clinical and cultural competence of short-term health staff.³⁵ The
53
54 acceptability of the service to local residents is not only a function of the cultural
55
56 competence of non-Aboriginal or Torres Strait Islander staff, but also the presence of
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3 Aboriginal staff, both clinical and non-clinical staff such as administrative officers, drivers
4
5 and groundsmen. These non-clinical staff are often long-serving and knowledgeable. Their
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7 varying numbers across clinics may also help to explain the variability in the results
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9 presented.^{35,37}
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16 **LIMITATIONS**

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19 This study relied on territory-wide, routinely collected data to test its hypotheses rather
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21 than collecting data prospectively using definitions and in formats that might have been
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23 optimal for the purpose. The routine collection is used to guide service delivery and is
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25 routinely reported at both NT and national levels. Its use for this study was not only guided
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27 by feasibility but also to demonstrate the wider utility of the collection. Nonetheless the use
28
29 of the existing collection contributed to both measurement noise and definitional
30
31 challenges which made underlying associations less evident. For example, the use of agency
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33 nurses in NT DoH remote clinics are recorded either in payroll data or in expenditure data,
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35 depending on the payment arrangements that NT DoH has with each nursing agency. For
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37 this study agency nurses recorded in the NT DoH payroll were included in turnover and
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39 stability figures, whereas work by agency nurses recorded in expenditure data were
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41 included in the estimation of agency nurse proportion. A further limitation was that it was
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43 not possible to allocate staff working in a supernumerary capacity in a remote health clinic
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45 to that clinic as this wasn't recorded in the administrative records used. Finally, the
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47 research relates to a very specific context of government-provided PHC in small, remote NT
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49 communities and the findings may not be generalisable to other health systems, service
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51 models, geographical settings or study populations.
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CONCLUSION

Two very clear findings emerge from this study. One is that decreased staff stability and increased use of short-term agency nurses is associated with deficits in quality of care for some clinics but not for others. Understanding the reasons for this variation would significantly aid the provision of high quality clinical care in remote Australia. The second is that the data needed to understand this important question of quality of care, and other related questions, are challenging to obtain. The public interest would be served by the development of health information systems and streamlined processes that facilitate analyses such as those undertaken here.

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Contributors

MPJ contributed to the design of the study and led analysis and drafting of the paper. JW led the conceptualisation and overall study design and contributed to drafting the paper. JSH contributed to the conceptualisation and design of the study and assisted with drafting the manuscript. SG, MR and DJR contributed to the design of the study and assisted with drafting the manuscript. All authors read and approved the final manuscript.

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10 11 12 **Competing interests statement**

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18 19 20 **Patient consent for publication**

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22 Not required.
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35 36 37 **Patient and public involvement**

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39 It was not appropriate or possible to involve patients or the public in the design, or conduct,
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41 or reporting, or dissemination plans of the research reported here.
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52 53 54 **Data sharing statement**

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3 The datasets generated and analysed during the current study are not publicly available due
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5 to identifiability of remote primary health care providers and the need to protect their
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8 privacy.
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10 11 12 13 **Author note**

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16 Original protocol for the study: The original protocol for the study is published and available
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Table 1: Study independent variables

Measure	Definition
Turnover rate	$= \frac{\text{total number of exits}^{\dagger} \text{ in defined period}}{\text{average number of employees in defined period}}$
Stability rate	$= \frac{\text{Number of employees at start of defined period who remain employed at end of defined period}}{\text{Number of employees at start of defined period}}$
Agency nurse proportion	$= \frac{\text{Agency – employed nurse FTE}}{\text{Total FTE nurse positions}}$

Table 2: Study dependent variables

Indicator name	Definition	Denominator Population	Source of data
<i>Child and maternal health</i>			
First antenatal visit	Number and proportion of regular clients who attended a first antenatal visit (at any health service locality) <ol style="list-style-type: none"> 1. Before 13 weeks gestation 2. At 20 weeks or more gestation 3. Any antenatal visit 	Resident women who gave birth to an Aboriginal or Torres Strait Islander baby	NT AHKPI
Fully immunised children	Number and proportion of Aboriginal or Torres Strait Islander children fully immunised at <ol style="list-style-type: none"> 1. 6 months to < 1 year 2. 1 year to <2 years 3. 2 years to <6 years 4. Any age and have received all age appropriate vaccinations 	Aboriginal or Torres Strait Islander resident children aged 6 months to <6 years	NT AHKPI
Anaemia test	Number and proportion of Aboriginal or Torres Strait Islander children who, in the past year have been tested for anaemia	Aboriginal or Torres Strait Islander resident children who are ≥ 6 months old and <5 years	NT AHKPI

Anaemia result	Number and proportion of Aboriginal or Torres Strait Islander children who, in the past year have been found to be anaemic	Aboriginal or Torres Strait Islander resident children who are ≥ 6 months old and < 5 years	NT AHKPI
Chronic Disease Management			
Glycated haemoglobin (HbA1c) test	Number and proportion of Aboriginal or Torres Strait Islander resident clients aged 15 years and over with Type 2 Diabetes Mellitus who have had a glycated haemoglobin (HbA1c) test in the past 12 months.	Aboriginal or Torres Strait Islander resident clients aged ≥ 15 years diagnosed with Type 2 Diabetes Mellitus	TLR
Glycated haemoglobin (HbA1c) result	Number and proportion of Aboriginal or Torres Strait Islander clients with Type 2 Diabetes Mellitus and whose most recent glycated haemoglobin (HbA1c) measurement within the past 12 months is $\leq 8\%$ (≤ 86 mmol/mol)	Aboriginal or Torres Strait Islander resident clients aged ≥ 15 years diagnosed with Type 2 Diabetes Mellitus and had glycated haemoglobin (HbA1c) tested	TLR
Angiotensin Converting Enzyme Inhibitor) and/or Angiotensin Receptor Blocker	Number and proportion of Aboriginal or Torres Strait Islander clients with Type 2 Diabetes Mellitus with albuminuria who are on Angiotensin Converting Enzyme Inhibitor) and/or an Angiotensin Receptor Blocker.	Aboriginal or Torres Strait Islander resident clients aged ≥ 15 years diagnosed with Type 2 Diabetes Mellitus and albuminuria	TLR

Non-smoking	Number and proportion of Aboriginal or Torres Strait Islander clients who are ex- or never smokers of cigarettes	Aboriginal or Torres Strait Islander residents aged ≥ 15 who have had their smoking status recorded	TLR
Preventive Health			
Pap smear tests	Number and proportion of eligible Aboriginal or Torres Strait Islander women who have had at least one Pap smear test during the last: <ol style="list-style-type: none"> 1. 2 years 2. 3 years 3. 5 years 	Aboriginal or Torres Strait Islander resident women aged 20-69 inclusive	NT AHKPI
Adult health check 15-55	Number and proportion of Aboriginal or Torres Strait Islander clients who have had a full adult health check.	Aboriginal or Torres Strait Islander resident clients aged 15 years to < 55 years	TLR
Adult health check 55+	Number and proportion of Aboriginal or Torres Strait Islander clients who have had a full adult health check.	Aboriginal or Torres Strait Islander resident clients aged ≥ 55 years	TLR

NTAHKPI Northern Territory Aboriginal Health Key Performance Indicator reports

TLR Traffic light reports

Table 3. Clinic characteristics averaged across 2011-2015

Characteristics	Mean	SD	Min	Max	N
Markers of staff employment stability					
Average annual head count	4.50	3.80	0.28	19.17	48
Turnover rate	0.07	0.03	0.00	0.18	48
Stability rate	0.40	0.14	0.00	0.77	48
Agency nurse proportion	0.16	0.09	0.00	0.42	48
<i>Quality indicators[†]</i>					
First antenatal visit (1. before 13 weeks' gestation)	0.49	0.16	0.17	0.96	47
First antenatal visit (2. at or before 20 weeks' gestation)	0.72	0.15	0.23	1.00	47
First antenatal visit (3. any antenatal care)	0.98	0.04	0.80	1.00	47
Fully immunised children (6-11 months)	0.88	0.08	0.63	1.00	47
Fully immunised children (12-23 months)	0.83	0.12	0.54	1.00	47
Fully immunised children (24-71 months)	0.80	0.08	0.58	0.935	47
Fully immunised children (any age)	0.81	0.08	0.60	0.93	47
Anaemia test	0.78	0.09	0.50	0.90	47
Anaemia result	0.17	0.05	0.06	0.30	47
Glycated haemoglobin (HbA1c) test	0.92	0.04	0.84	1.00	46
Glycated haemoglobin (HbA1c) result ≤8%	0.48	0.10	0.23	0.71	47

Angiotensin Converting Enzyme Inhibitor) and/or Angiotensin Receptor Blocker	0.84	0.10	0.59	1.00	46
Non-smoking	0.52	0.14	0.24	0.73	47
Adult health check 55+	0.34	0.12	0.09	0.72	47
Adult health check 15-54	0.42	0.15	0.11	0.75	47
Pap smear 2yrs	0.50	0.12	0.20	0.79	47
Pap smear 3yrs	0.40	0.07	0.18	0.55	47
Pap smear 5yrs	0.46	0.06	0.24	0.56	47

†One of the 48 health clinics did not independently report on any quality indicators during the study period. A second health clinic did not report on Glycated haemoglobin tests and Angiotensin Converting Enzyme Inhibitor and/or Angiotensin Receptor Blocker quality indicators.

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Table 4. Associations between markers of staff employment stability and quality indicators

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Indicator	Staffing	Slope	Lower	Upper	p-value	ASD
	measure					
First antenatal visit (before 13 weeks' gestation)	Turnover	0.023	-0.010	0.056	0.2	0.33
	Agency nurse	-0.060	-0.178	0.059	0.3	1.03
	Stability	0.001	-0.113	0.115	>0.9	0.55
First antenatal visit (at or before 20 weeks' gestation)	Turnover	0.026	-0.018	0.070	0.3	0.27
	Agency nurse	-0.088	-0.231	0.056	0.2	1.10
	Stability	0.008	-0.091	0.107	0.9	0.44
First antenatal visit (any antenatal care)	Turnover	-0.001	-0.006	0.004	0.7	0.13
	Agency nurse	0.015	-0.028	0.058	0.5	0.38
	Stability	0.007	-0.015	0.030	0.5	0.27
Fully immunised children (6-11 months)	Turnover	-0.061	-0.119	-0.002	0.04	0.36
	Agency nurse	0.022	-0.135	0.179	0.8	1.21
	Stability	0.011	-0.073	0.095	0.8	0.51
Fully immunised children (12-23 months)	Turnover	-0.001	-0.017	0.015	0.9	0.16
	Agency nurse	-0.049	-0.155	0.057	0.4	0.63
	Stability	-0.017	-0.062	0.028	0.5	0.25
Fully immunised children (24-71 months)	Turnover	-0.012	-0.030	0.006	0.2	0.11
	Agency nurse	-0.056	-0.122	0.009	0.09	0.43
	Stability	0.002	-0.034	0.037	0.9	0.23
Fully immunised children	Turnover	0.002	-0.008	0.013	0.7	0.10

(any age)	Agency nurse	-0.061	-0.118	-0.005	0.03	0.38
	Stability	0.004	-0.025	0.033	0.8	0.19
Anaemia result	Turnover	0.011	-0.025	0.048	0.5	0.10
	Agency nurse	0.019	-0.055	0.093	0.6	0.62
	Stability	0.042	-0.008	0.092	0.1	0.24
Anaemia test	Turnover	0.017	0.000	0.034	0.06	0.11
	Agency nurse	0.023	-0.046	0.092	0.5	0.55
	Stability	0.002	-0.041	0.045	>0.9	0.32
Glycated haemoglobin (HbA1c) test	Turnover	-0.006	-0.024	0.012	0.5	0.11
	Agency nurse	-0.003	-0.076	0.070	0.9	0.57
	Stability	0.015	-0.015	0.044	0.3	0.20
Glycated haemoglobin (HbA1c) result	Turnover	-0.006	-0.022	0.010	0.5	0.24
	Agency nurse	-0.037	-0.026	0.101	0.3	0.27
	Stability	-0.036	-0.066	-0.007	0.02	0.26
Angiotensin Converting Enzyme Inhibitor) and/or Angiotensin Receptor Blocker	Turnover	-0.025	-0.060	0.010	0.2	0.24
	Agency nurse	0.053	-0.104	0.210	0.5	0.35
	Stability	0.044	-0.010	0.097	0.1	0.34
Non-smoking	Turnover	-0.007	-0.019	0.005	0.3	0.28
	Agency nurse	0.005	-0.043	0.053	0.8	0.28
	Stability	-0.005	-0.033	0.023	0.7	0.29
Pap smear 2yrs	Turnover	-0.007	-0.019	0.005	0.2	0.09
	Agency nurse	-0.058	-0.127	0.011	0.1	0.47
	Stability	0.006	-0.038	0.051	0.8	0.20

Pap smear 3yrs	Turnover	-0.021	-0.038	-0.004	0.01	0.18
	Agency nurse	-0.053	-0.137	0.030	0.2	0.73
	Stability	0.050	-0.030	0.130	0.2	0.51
Pap smear 5yrs	Turnover	-0.023	-0.041	-0.005	0.01	0.20
	Agency nurse	-0.048	-0.155	0.059	0.4	0.83
	Stability	0.057	-0.030	0.143	0.2	0.59
Adult health check aged 15-55	Turnover	0.031	-0.003	0.066	0.08	0.12
	Agency nurse	0.129	-0.036	0.294	0.1	0.59
	Stability	-0.056	-0.119	0.006	0.08	0.38
Adult health check aged 55+	Turnover	0.024	-0.040	0.087	0.5	0.21
	Agency nurse	0.265	0.073	0.457	0.007	1.01
	Stability	-0.027	-0.145	0.091	0.7	0.56

^AStandard deviation (SD) of clinic-specific estimates of association

Table 5. Cluster characteristics

	Mean			SD			Clinic-months		
	1	2	3	1	2	3	1	2	3
Cluster Number	1	2	3	1	2	3	1	2	3
Number of clinics	9	16	19	9	16	19			
<i>Mean^A</i>									
Number of staff exits	2.20	0.74	0.79	2.39	1.02	0.99	167	297	350
Turnover rate	0.22	0.16	0.29	0.22	0.23	0.39	167	297	347
Stability rate	0.46	0.64	0.43	0.11	0.14	0.12	203	361	426
Agency nurse proportion	0.19	0.17	0.20	0.12	0.14	0.19	167	271	346
<i>SD^A</i>									
Staff exits	2.18	0.88	0.95	0.82	0.36	0.31	203	361	426
Turnover rate	0.14	0.19	0.33	0.04	0.06	0.06	203	361	426
Stability rate	0.21	0.21	0.37	0.08	0.08	0.12	203	361	426
Agency nurse proportion	0.10	0.13	0.17	0.03	0.04	0.05	203	339	426
<i>Traits^B</i>									
Index of Relative Socio-economic Advantage and Disadvantage	652	746	709	84	122	137	9	16	19
Google distance to Darwin or Alice Springs	313	267	332	222	167	220	9	16	19
Predominantly non- Aboriginal: % (count)	0.0	6.3	15.8	0	1	3	9	16	19

^ABased on multiple measurements per clinic to reflect variation in these traits over time within clinics

^BBased on a single measurement per clinic since this trait does not vary within each clinic over the time period studied

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Table 6. Variation in indicators across clusters

	Mean				SD			
	Clusters (3)			Overall	Clusters (3)			Overall
	1	2	3		1	2	3	
First antenatal visit by 13 weeks	0.50	0.49	0.48	0.49	0.10	0.13	0.15	0.13
First antenatal visit by 20 weeks	0.74	0.75	0.70	0.72	0.06	0.14	0.15	0.14
First antenatal visit anytime	0.98	0.98	0.98	0.98	0.01	0.06	0.03	0.04
Child immunisation 6-11m	0.86	0.90	0.89	0.89	0.07	0.08	0.07	0.08
Child immunisation 12-23m	0.84	0.84	0.87	0.85	0.10	0.12	0.11	0.11
Child immunisation 24-71m	0.82	0.78	0.81	0.80	0.09	0.09	0.07	0.08
Child immunisation (all)	0.83	0.80	0.82	0.81	0.08	0.09	0.06	0.08
Anaemia test	0.81	0.79	0.79	0.79	0.06	0.06	0.09	0.07
Anaemia result **	0.21	0.16	0.16	0.17	0.03	0.06	0.06	0.06
Glycated haemoglobin (HbA1c) test	0.90	0.93	0.93	0.92	0.04	0.04	0.04	0.04
Glycated haemoglobin (HbA1c) result	0.48	0.50	0.48	0.49	0.09	0.07	0.13	0.10
Angiotensin Converting Enzyme Inhibitor) and/or Angiotensin Receptor Blocker**	0.74	0.84	0.88	0.84	0.11	0.05	0.08	0.09
Non-smoking	0.49	0.52	0.53	0.52	0.14	0.13	0.15	0.14
Pap smear 2 years	0.51	0.52	0.50	0.51	0.12	0.10	0.12	0.11
Pap smear 3 years	0.40	0.42	0.41	0.41	0.07	0.07	0.07	0.07
Pap smear 5 years	0.45	0.47	0.46	0.46	0.05	0.05	0.05	0.05
Adult health check aged 15-54	0.31	0.34	0.37	0.35	0.13	0.14	0.12	0.12

	Mean				SD			
	Clusters (3)			Overall	Clusters (3)			Overall
	1	2	3		1	2	3	
Adult health check aged 55+	0.45	0.45	0.38	0.42	0.15	0.15	0.16	0.15

** p<0.001

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Table 7. Variation in mean associations across clusters

(Describe slopes by clusters-results 5.12.19.docx)

Cluster	Stability			Turnover			Agency nurse %			IV contrasts		
	1	2	3	1	2	3	1	2	3	1	2	3
First antenatal visit 13wks	0.176	-0.012	-0.110	-0.058	0.061	0.013	0.029	0.002	-0.289			
First antenatal visit 20wks	0.180	0.065	-0.046	-0.020	0.023	-0.091	0.101	0.084	-0.261			
First antenatal visit any	-0.050	-0.113	0.054	-0.015	0.023	-0.038	-0.082	0.201	-0.018	*		
Immunisation 6-11m	0.115	-0.181	0.026	-0.155	0.011	0.117	0.087	-0.263	0.304			
Immunisation 12-23m	0.083	0.113	-0.079	0.002	0.012	0.039	0.075	-0.106	0.362			
Immunisation 24-71m	0.114	0.107	-0.002	0.057	0.039	-0.005	-0.174	-0.303	-0.117			
Immunisation overall	0.128	0.098	-0.008	0.031	0.034	-0.010	-0.106	-0.242	-0.016			
Anaemia test	0.162	0.027	0.107	-0.000	0.008	-0.032	-0.050	0.034	0.050			
Anaemia result	-0.011	-0.023	0.065	-0.016	-0.001	0.006	-0.032	0.118	0.142			
Glycated haemoglobin (HbA1c) test	0.115	-0.467	0.152	0.311	0.050	-0.033	0.298	-0.392	-0.352			
Glycated haemoglobin (HbA1c) result	-0.060	0.048	0.233	-0.078	0.014	0.039	-0.020	-0.183	-0.060			
Angiotensin Converting Enzyme Inhibitor) and/or Angiotensin Receptor Blocker	-1.048	-0.015	0.000	-0.615	-0.257	-0.046	0.298	-0.392	-0.352			
Non-smoking	0.067	0.012	-0.017	0.024	0.037	-0.019	-0.021	0.002	0.122			
Pap smear 2yrs	0.173	-0.015	-0.016	-0.037	0.003	0.024	-0.086	-0.101	-0.061	*		
Pap smear 3yrs	-0.331	-0.041	-0.012	-0.084	0.061	-0.052	-0.070	-0.382	0.054			

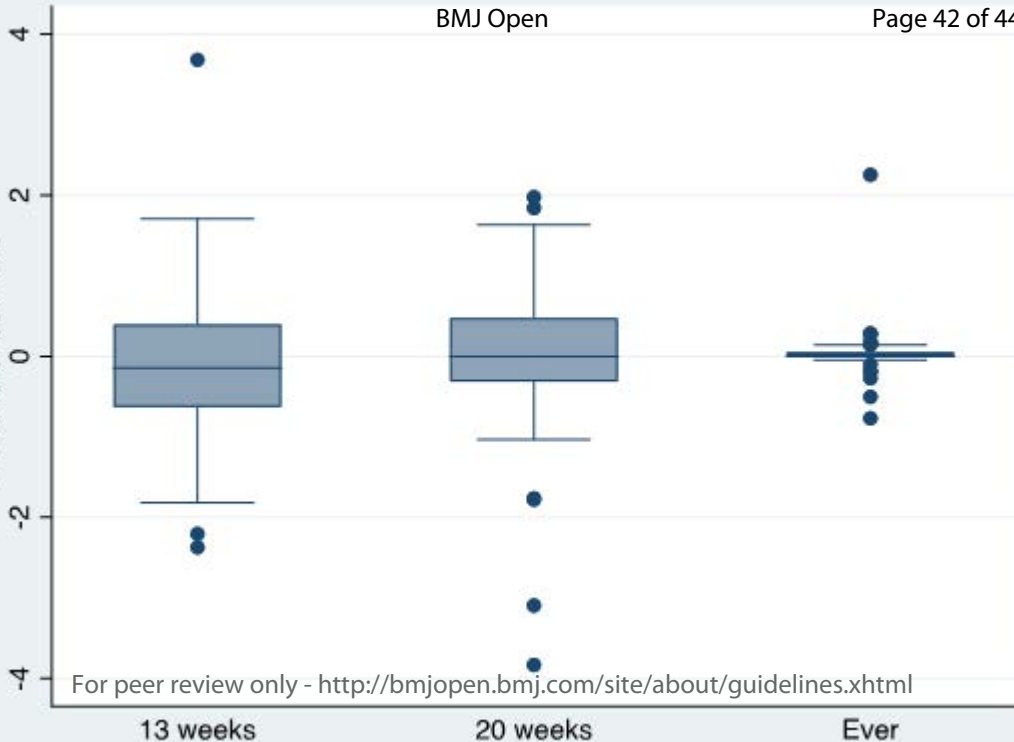
Cluster	Stability			Turnover			Agency nurse %			IV contrasts		
	1	2	3	1	2	3	1	2	3	1	2	3
Pap smear 5yrs	-0.371	-0.065	0.017	-0.086	0.061	-0.058	-0.031	-0.385	0.055			
Adult health check 15-54	-0.220	-0.009	-0.229	-0.464	-0.278	-0.124	0.733	0.077	-0.098			
Adult health check 55+	-0.478	0.218	-0.382	-0.403	-0.169	-0.126	2.825	0.310	0.315			

* $p < 0.05$

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3 Figure 1. Distribution of clinic-specific associations between proportional use of agency
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6 nurses and antenatal care quality of care indicators
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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	8
		(b) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-10
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	n/a
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-11
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	10-11
		(b) Describe any methods used to examine subgroups and interactions	10-11
		(c) Explain how missing data were addressed	See comment beneath Table 3
		(d) If applicable, explain how loss to follow-up was addressed	n/a
		(e) Describe any sensitivity analyses	n/a

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Table 3 (numbers of participating health services)
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 5, reported by clinic clusters
		(b) Indicate number of participants with missing data for each variable of interest	Table 3
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	n/a – time course is summarized in analysis
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a – relevant confounders not established
		(b) Report category boundaries when continuous variables were categorized	n/a
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Table 5
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-16
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18-19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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BMJ Open

Effects of turnover and stability of health staff on quality of care in remote communities of the Northern Territory, Australia: a retrospective cohort study

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3 Title: Effects of turnover and stability of health staff on quality of care in remote
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5 communities of the Northern Territory, Australia: a retrospective cohort study
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10 Authors: Michael P Jones,¹ Yuejen Zhao,² Steven Guthridge,³ Deborah Jane Russell,⁴ Mark
11
12 Ramjan,⁵ John S Humphreys,⁶ John Wakerman⁴
13
14
15
16
17

18 Author affiliations
19

20 ¹Faculty of Human Sciences, Macquarie University, Sydney, New South Wales,
21
22 Australia
23

24 ²NT Department of Health, Innovation and Research, Darwin, Northern Territory,
25
26 Australia
27

28 ³Menzies School of Health Research, Charles Darwin University, Casuarina, Northern
29
30 Territory, Australia
31
32

33 ⁴Menzies School of Health Research, Charles Darwin University, Alice Springs, Northern
34
35 Territory, Australia
36
37

38 ⁵Population and Primary Health Care, Top End Health Services, NT Department of Health,
39
40 Darwin, NT, Australia
41
42

43 ⁶Monash Rural Health, Monash University, Bendigo, Victoria, Australia
44
45
46
47
48
49
50
51

52 Corresponding author:
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54
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56 Prof Michael P. Jones
57

58 Psychology Department
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Macquarie University

North Ryde NSW 2109

Australia

fax: n/a

email: mike.jones@mq.edu.au

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1
2
3 Abstract
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8 **Objectives** To evaluate the relationship between markers of staff employment stability and
9
10 use of short-term health care workers with markers of quality of care. A secondary objective
11
12 was to identify clinic-specific factors which may counter hypothesised reduced quality of
13
14 care associated with lower stability, higher turnover or higher use of short-term staff.
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16

17 **Design** Retrospective cohort study (NT Department of Health Primary Care Information
18
19 Systems).
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21

22 **Setting** All 48 Government primary health care clinics in remote communities in Northern
23
24 Territory, Australia (2011-15).
25
26

27 **Participants** 25,413 patients drawn from participating clinics during the study period.
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29

30 **Outcome Measures** Associations between independent variables (Resident Remote Area
31
32 Nurse (RAN) and Aboriginal Health Practitioner (AHP) turnover rates, stability rates and the
33
34 proportional use of agency nurses) and indicators of health service quality in child and
35
36 maternal health, chronic disease management and preventive health activity were tested
37
38 using linear regression, adjusting for community and clinic size. Latent class modelling was
39
40 used to investigate between-clinic heterogeneity.
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44 **Results** The proportion of resident Aboriginal clients receiving high quality care as measured
45
46 by various quality indicators varied considerably across indicators and clinics. Higher quality
47
48 care was more likely to be received for management of chronic diseases such as diabetes
49
50 and least likely to be received for general/preventive adult health checks. Many indicators
51
52 had target goals of 0.80 which were mostly not achieved. The evidence for associations
53
54 between decreased stability measures or increased use of agency nurses and reduced
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56 achievement of quality indicators was not supported as hypothesised. For the majority of
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3 associations, the overall effect sizes were small (close to zero) and failed to reach statistical
4
5 significance. Where statistically significant associations were found, they were generally in
6
7 the hypothesised direction.
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10 **Conclusions** Overall, minimal evidence of the hypothesised negative effects of increased
11
12 turnover, decreased stability and increased reliance on temporary staff on quality of care
13
14 was found. Substantial variations in clinic-specific estimates of association were evident,
15
16 suggesting that clinic-specific factors may counter any potential negative effects of
17
18 decreased staff employment stability. Investigation of clinic-specific factors using latent
19
20 class analysis failed to yield clinic characteristics that adequately explain between-clinic
21
22 variation in associations. Understanding the reasons for this variation would significantly aid
23
24 the provision of clinical care in remote Australia.
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33 **Strengths and limitations of this study**

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35 • Data are for an entire population—remote living residents in communities serviced
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37 by Northern Territory Department of Health;
- 38
39 • Analyses adjusted for key potential confounders, including remote community
40
41 population size, average number of employees, Euclidean distance in kilometres to
42
43 the major centres of Darwin or Alice Springs (whichever was closest) and Euclidean
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45 distance in kilometres to the nearest of the five NT hospitals;
- 46
47 • The major limitation was the retrospective design, relying on routinely collected and
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49 administrative data.
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INTRODUCTION

Australia is a geographically large country (7.7 million square kilometres) with a concentration of both population and health care resources along its eastern and southern seaboard.¹ In 2019, 69% of the Australian estimated resident population lived in the eastern and southern seaboard State capital cities and three large regional towns (Newcastle, Wollongong and Geelong)². A relatively small fraction of the Australia's health care resources are used to service the primary health care (PHC) needs of its extensive rural and remote populations, with the National Rural Health Alliance estimating a large rural health expenditure deficit of approximately \$2bn per annum.³

In non-metropolitan Australia, access to PHC is further limited by the combination of high health need and the need for cultural competency when providing health services for Australian Aboriginal and Torres Strait Islander populations who have much greater health needs across both acute and chronic conditions relative to all Australians.⁴ This is particularly apparent in the Aboriginal population of the Northern Territory (NT) where chronic diseases such as cardiovascular disease and diabetes are up to four times more prevalent and life expectancy at birth is approximately 16 years less than the corresponding measure for Australia as a whole.⁵ While continuity of care is important for all patients, it is especially important for vulnerable populations, such Aboriginal and Torres Strait Islander populations living in small, isolated communities.^{6,7} Continuity of high quality PHC can help ensure chronic health conditions are prevented where possible, and diagnosed early and managed optimally where not, ensuring that patients avoid potentially preventable hospitalisations.^{8,9}

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3 The long-standing geographical maldistribution of general practitioners (GPs) has been the
4 target of numerous programs by government and health professional bodies over a long
5
6 period, with only mixed success.¹⁰⁻¹² In geographically remote areas, PHC services are more
7
8 commonly provided by resident Remote Area Nurses (RANs) and Aboriginal Health
9
10 Practitioners (AHPs), supported by visiting medical, nursing and allied health professionals,
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12 and other short-term health workers engaged on a fly-in fly-out or drive-in-drive-out basis
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14 and often engaged through employment agencies.¹³ While resident staff remain in a
15
16 community from months to several years and therefore get to know and be known by
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18 community members, short-term employment agency staff may only be in a community for
19
20 a period of weeks. Such short tenure makes continuity of care less attainable and staff less
21
22 able to develop appropriate levels of cultural and social awareness to engage effectively
23
24 with local residents, leading to lower utilisation of PHC services.^{14,15} Lower PHC utilisation
25
26 may contribute to poorer health outcomes: better access and utilisation of PHC by
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28 Aboriginal people living in remote NT communities and remote outstations is associated
29
30 with lower mortality, lower morbidity and more cost-effective health care, though the
31
32 association between PHC utilisation and hospitalisations is more complex.¹⁶⁻¹⁸

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35 A further potential consequence of poor continuity of care and cultural attunement of
36
37 health care staff is reduced quality of care. Short-term staff may focus on acute care needs
38
39 and neglect or have insufficient awareness of preventive and chronic care needs, such as
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41 health promotion, health screening, monitoring chronic health conditions, encouraging
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43 smoking cessation or checking the immunisation status of infants and adults. Most, though
44
45 not all, research shows that continuity of PHC provider is associated with better control of
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47 type 2 diabetes¹⁹⁻²² as well as increased provision of preventive care services including
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49 immunisations and screening for hypertension, alcohol abuse and high cholesterol levels.²³
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3 However, the extent to which continuity of care and measures of staff turnover and stability
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5 are associated with quality of care in complex cross-cultural contexts characterised by
6
7 reliance on short-term PHC providers is not well-understood. While research using a case
8
9 study design suggests that in remote NT, PHC workforce turnover is the most significant
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11 barrier to successful quality improvement, the association between workforce turnover or
12
13 stability and quality of PHC in remote NT is yet to be verified using stronger study designs.²⁴
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18 This article therefore seeks to evaluate the relationship between markers of staff
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20 employment stability and turnover and use of short-term PHC staff with markers of quality
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22 of care, in order to determine whether these are detrimental to the care received by
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24 residents of remote locations. We hypothesised that stability would be positively associated
25
26 with quality measures and that turnover and the use of short-term PHC staff would be
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28 negatively associated with quality measures. We also sought to identify factors which may
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30 counter hypothesised reduced quality of care associated with lower stability, higher
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32 turnover or higher use of short-term staff.
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41 **METHODS**

42 43 44 45 46 Study design and setting

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50 This observational study has a retrospective cohort design: the cohort consists of patients,
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52 RANs, AHPs and short-term staff of 48 NT Department of Health (DoH) remote clinics during
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54 the period 2011-2015, inclusive.
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Data

Data were provided by the NT DoH. Workforce data were obtained from the Personnel Information and Payroll Systems (PIPS) dataset. PIPS data provided comprehensive, individual-level, de-identified information on all RANs and AHPs paid directly through the NT DoH payroll. These data were used to ascertain the number of RAN and AHP exits from remote health services and to calculate annual turnover and 12-month stability rates. The Government Accounting System (GAS) was used to identify labour hire costs for agency nurses paid directly by employment agencies (hereafter termed agency nurses). The aggregated full-time equivalent (FTE) for agency-employed nurses working in remote health services was derived using the standard NT DoH formula of agency labour expenses divided by twice the departmental annual average nurse personnel cost.²⁵

Quarterly Traffic Light Reports were produced by NT DoH staff for each remote community as part of the Chronic Conditions Management Model.²⁶ The combined Traffic Light Report, which has retrospective data for all NT DoH remote health clinics, was the source of data for twelve quality indicators. Data for some indicators were available every 3 months from March 2012 through to November 2015, though reporting on other indicators commenced at a later date (the latest being August 2013). Additionally, routine health services reports of NT Aboriginal Health Key Performance Indicators (AHKPIs), extracted from the NT DoH Primary Care Information Systems (PCIS), were the source of data for a further twelve quality indicators. The NT AHKPI data related to outcomes for 25,413 patients. NT AHKPI data were available for 48 of 53 NT DoH clinics in the larger study. NT AHKPI data were not available for five clinics that used a different PHC electronic clinical records management system.

Measures

In this study the main independent variables were clinic-level measures of RAN and AHP annual turnover and 12-month stability, and the proportional use of agency nurses.

Hereafter, these three measures will be collectively referred to as markers of staff employment stability. We used three different measures of staff employment stability because of the complexities involved in staffing remote health services, the known heavy reliance on agency nurses in remote NT and because none of these workforce metrics on their own provide a sufficiently comprehensive picture of workforce mobility patterns.^{27,28}

The three main workforce metrics are defined in Table 1. An additional metric, the number of exits from a health service (which is the numerator of the turnover metric), was used in the Latent Class Analysis.

[Table 1 about here]

Additional independent variables (potential confounders) included remote community population size, average number of employees, Euclidean distance in kilometres to the major centres of Darwin or Alice Springs (whichever was closest) and Euclidean distance in kilometres to the nearest of the five NT hospitals (distances calculated using google maps).

The socioeconomic status of the community in which each clinic was located was measured using the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) for clinic catchment areas' average scores for Indigenous localities (ILOC)²⁹ as measured in the 2011 national census conducted by the Australian Bureau of Statistics (ABS). The Aboriginal composition of each community was measured as the proportion of the resident population

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2
3 identifying as an Aboriginal person in the 2016 census.³⁰ The latter was dichotomised into
4 whether or not Aboriginal people comprised a majority of the population (>50%) in the
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8 community.

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10 We were initially provided with data for 24 quality indicators (several of which were the
11
12 same indicator but measured using different data sources at slightly different time points).
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14 Some indicators also had more than one component. For example, child immunisation was
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16 categorised into different age groups and glycosylated haemoglobin (HbA1c) results were
17
18 categorised into different levels of glycaemic control. Our aim was to examine a sufficient
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20 range of indicators of quality of care to ensure that a reasonable spectrum of PHC activities
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22 was covered by the indicators, rather than to be exhaustive. We therefore grouped quality
23
24 indicators into three categories: child and maternal health; chronic disease management;
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26 and preventive health activity, and reduced the number of indicators, ensuring there were
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28 at least three indicators within each category. (Table 2) The reporting period for the
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30 indicators ranged from six months for the HbA1c test reported in the NT AHKPIs, up to two
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32 years.
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40 [Insert Table 2 about here]

41 42 43 44 **Statistical approach**

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47 The associations between markers of staff employment stability (independent variables)
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49 and markers of quality (dependent variables) were assessed using linear regression which
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51 employed the linearisation method³¹ to estimate the within-clinic correlation and adjust
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53 standard errors accordingly. Each dependent variable was expressed as the sequential
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55 change from the previous period (month, quarter or half year) to express change in
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57 indicator status. Due to the non-Normal distribution of some outcome variables, formal
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3 statistical inference employed the nonparametric bootstrap method. The direction and
4
5 strength of the associations between independent variables and dependent variables is
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7 reported through the regression slopes (β coefficients) along with 95% confidence interval
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9 upper and lower limits and two-tailed p-values. Analyses adjusted for potential
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11 confounders. It is noted that this is an exploratory study, the first of its kind in this
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13 environment, and therefore no allowance for multiple hypothesis testing has been made.
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15 We therefore interpret statistically significant results as indicative rather than definitive.
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21 Clinic-specific estimates of the associations between independent variables and dependent
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23 variables were also calculated using linear regression and the standard deviation of
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25 coefficients is reported as a measure of between-clinic variation in the influence of markers
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27 of staff employment stability on quality of care. To facilitate understanding of the
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29 proportion of clinics that experience positive, negative or no association with a given
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31 measures of staffing, standardized coefficient were classified as ≤ -0.1 , > -0.1 to < 0.1 and
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33 ≥ 0.1 .
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39 Considerable between-clinic heterogeneity was identified. To aid in understanding clinic
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41 profiles that are associated with stronger or weaker associations, clinics were clustered into
42
43 mutually exclusive groups based on their markers of staff employment stability using latent
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45 class models.³² A cluster membership probability is calculated for each cluster for each
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47 clinic and clinics are allocated to the cluster for which they have highest probability of
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49 membership. Variation between clusters of clinics with respect to association (slopes)
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51 between markers of staff employment stability and quality measures were examined to
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53 generate hypotheses concerning clinic factors that might counter the effects of reduced
54
55 staffing stability or increased turnover or use of agency nurses. The clustering process can
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1
2
3 be hindered by multivariate outliers that have undue influence on the cluster solution.^{33,34}
4
5 For this reason a two-cluster solution was set as a first step in which forty-four clinics were
6
7 allocated to one cluster and just four into the second. The analysis was then repeated on
8
9 the forty-four remaining clinics. The four clinics omitted from the latent class analysis
10
11 reported (due to them being outliers that could unduly influence further analysis) were
12
13 statistically significantly associated with lower stability ($p=0.04$), higher turnover ($p=0.002$)
14
15 and lower proportional use of agency nurses ($p=0.004$). Quality-of-care measures for the
16
17 four clinics that were omitted from the modelling as multivariate outliers were also
18
19 compared with the clinics included in the analysis. Given the very small number of clinics
20
21 omitted it is difficult to make any firm conclusions, and no differences reached statistical
22
23 significance, but there was a general trend for these clinics to have lower rates of meeting
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25 quality criteria.
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33 **Patient and public involvement**

34
35 It was not appropriate or possible to involve patients or the public in the design, or conduct,
36
37 or reporting, or dissemination plans of the research reported here. Nevertheless, this study
38
39 formed part of a broader project which used mixed-methods, including interviews and focus
40
41 group discussions with clinic users. The results of the broader project were disseminated to
42
43 participants and the analysis of the broader project informed the interpretation of this
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45 study's findings and discussion.
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53 **RESULTS**

54
55 Included clinics were relatively small with respect to staffing (Table 3) and located long
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57 distances from the major NT centres of Darwin and Alice Springs, on average 304 kilometres
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3 (SD=191) from the nearest of these. The average clinic had 4-5 staff at any point in time
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5
6 although there was considerable variation between clinics with some having less than one
7
8 and others almost twenty. Similarly, there was considerable between-clinic variation in the
9
10 measures of turnover, stability and use of short-term staff, with some clinics having mean
11
12 scores approximately twice the overall average. Agency nurses made up a little under 20%
13
14 of remote staff, on average, although these values also varied considerably between clinics
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16 with the highest being over 40%.
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21 [Insert Table 3 about here]
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25
26 The proportion of resident Aboriginal clients receiving high quality care as measured by the
27
28 various quality indicators varied considerably across indicators and clinics (with some
29
30 variation also evident by dataset). On average, high quality care was more likely to be
31
32 received for management of chronic disease such as diabetes and least likely to be received
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34 for general/preventive adult health checks. Many indicators used in the Traffic Light Report
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36 program had target goals of 0.80. These target goals were mostly not achieved.
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44 [Insert Table 4 about here]
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50 The evidence for associations between markers of staff employment stability and reduced
51
52 performance as measured by markers of quality was not supported as hypothesised. For the
53
54 majority of associations reported in Table 4 the overall effect sizes (slopes) were small (close
55
56 to zero) and failed to reach statistical significance. Where statistically significant associations
57
58 were found, however, they were generally in the hypothesised direction. Examples include
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1
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3 increased turnover being associated with lower proportions of eligible women having pap
4 smears within the previous five years and lower proportions of children being fully
5 immunised (6-11 months); and increased stability associated with glycaemic control
6 (HbA1c \leq 8%). There were however exceptions, such as where increased turnover was
7 associated with higher achievement of adult 55+ health checks.
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19 [Insert Figure 1 about here]
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21
22 A common finding was considerable between-clinic variation in markers of staff
23 employment stability and quality indicators, although the degree of variation between
24 clinics was inconsistent and differed with different levels of a quality indicator. Figure 1
25 illustrates this for the association between proportion of agency nurse and three levels of
26 provision of antenatal care where the median slope is close to zero for all three levels of the
27 antenatal care indicator. During the first and second trimester, the association with
28 proportion of agency nurses appears to vary widely between positive and negative values
29 while for receiving care at any time before the end of pregnancy there is relatively little
30 between-clinic variation. In this example, if we calculate standardized mean differences
31 (SMDs) based on the SD of the 13 week clinic-specific estimates and classify each clinic's
32 estimate as negative, effectively zero or positive based on thresholds of \leq -0.1, between -0.1
33 and +0.1 or \geq 0.1 the percentage of clinics with negative, nil or positive associations with
34 agency nurse proportion were 53%, 7%, 40% (respectively) at 13 weeks, 44%, 14%, 42% at
35 20 weeks and 12%, 65%, 23% by end of pregnancy. Hence the overall association effect size
36 can hide considerable variation in the direction and magnitude of association in individual
37 clinics.
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[Insert Table 5 about here]

Subsequent to finding the considerable variation between clinics described above, latent class analysis was undertaken which identified three clusters of clinics (columns labelled 1, 2 and 3 in Table 5) which appear to represent a gradient in the markers of staff employment stability. Cluster 1 is distinguished by comparatively high service populations, larger staff numbers and correspondingly high mean number of staff exits but also high variance in staff exits over time. This cluster has levels of average stability and turnover that are in between those of Clusters 2 and 3. The second cluster services smaller populations than cluster 1 and has correspondingly smaller staff numbers. It also has comparatively low average and variance in staff exits, lower turnover and higher stability scores, hence represents a hypothetically desirable group of clinics on average. The third cluster services the smallest populations, on average, and has correspondingly the lowest average staff numbers. It lies between the first and second with lower mean and variance over time in staff exits than Cluster 1 but has the highest turnover (indicative of smaller clinic size than Cluster 1 clinics), the lowest stability and the highest proportional use of agency nurses, hence represents a hypothetically undesirable group of clinics on average. There was overall less variation in the mean proportion of agency nurses between clusters, with Cluster 2 having the lowest proportion (17%) and Cluster 3 the highest (20%).

[Insert Table 6 about here]

In general, there was not clinically meaningful and statistically significant variance in quality indicator achievement between clusters (Table 6). Exceptions were lower use of Angiotensin

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3 Converting Enzyme Inhibitor and/or Angiotensin Receptor Blocker in Cluster 1 than Clusters
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5 2 and 3 and higher rates of childhood anaemia in clinics in cluster 1 than in Clusters 2 and 3.
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8 However in general the clusters are not differentiated with respect to indicators of quality
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10 of care.
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13 [Insert Table 7 about here]
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19 Table 7 presents the mean association effect sizes across clusters according to the markers of staff
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21 employment stability and quality indicator combinations. In general clusters did not differ
22
23 substantially or in a statistically significant way with respect to strength/direction of the association.
24
25 Exceptions included the association between stability and antenatal care at any time during
26
27 pregnancy for which Cluster 1 reported a statistically significant negative association; and pap
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29 smears at two years, for which Cluster 1 reported a statistically significant positive association with
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31 stability. All other clusters reported no association.
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38 DISCUSSION

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43 Overall, minimal evidence of the hypothesised negative effects of increased turnover,
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45 decreased stability and increased reliance on temporary staff on quality of care was found.
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48 In a small number of cases there were statistically significant associations in the
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50 hypothesised direction, a smaller number in a direction opposite to that hypothesised, but
51
52 the majority yielded overall association measures (slopes) that were close to zero and failed
53
54 to reach statistical significance (Table 2). While these findings could indicate that the
55
56 hypothesised negative effects of staffing instability on quality of care are not supported by
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58 the evidence, there are several pointers that on-the-ground reality might not be that simple.
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3 First, while the overall estimates of association were all close to zero, there was substantial
4 variation in the clinic-specific estimates, meaning that in some clinics quality was negatively
5 associated with higher turnover, lower stability and higher use of short-term staff but in
6 other clinics quality was unrelated or even positively related with these measures. The
7 latter, counter-hypothesised results might reflect random chance but they might also reflect
8 clinic-specific factors that counter the potential negative effects of decreased workforce
9 stability, increased turnover and increased use of short-term staff. An illustration of the
10 fraction of clinics with negative, effectively zero or positive associations was given for
11 antenatal care as the quality indicator and proportion of agency nurses as the stability
12 measure. Where the association was clearly not statistically significant 65% of clinics had
13 estimate associations that were effectively zero, with the remainder split between some
14 degree of negative or positive associations. A clustering of clinics based on markers of staff
15 employment stability failed to yield clinic groupings that explain the between-clinic variation
16 in associations (Table 7).

17
18 Alternate explanations of this variability might include a number of unquantified local
19 factors. For example, a competent clinic manager may be able to manage an unstable
20 workforce more effectively, thus mitigating the deficits that might otherwise have
21 occurred.³⁵ A robust Continual Quality Improvement program, visiting outreach health
22 staff, and clinic-level data reports may also counter any negative effects of employment
23 instability. Heavy reliance on short-term agency nurses might not be as detrimental as
24 hypothesised if some of these nurses return repeatedly to the same clinic or group of clinics,
25 and thus have local knowledge and long-standing relationships with residents which
26 facilitate continuity of care.³⁶ Or it may be that in some instances skilled agency nurses
27 enable resident RANs to take planned annual leave or undertake professional development,

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3 rather than having a stream of inexperienced or poorly prepared agency nurses filling
4
5 longstanding vacancies at short notice.³⁵ In these ways, the administrative data might
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7 indicate greater instability in the workforce than is actually experienced in terms of
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9 continuity of care on the ground.
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13 Other factors that cannot be readily quantified that may contribute to the observed
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15 variability include both the clinical and cultural competence of short-term health staff.³⁵ The
16
17 acceptability of the service to local residents is not only a function of the cultural
18
19 competence of non-Aboriginal or Torres Strait Islander staff, but also the presence of
20
21 Aboriginal staff, both clinical and non-clinical staff such as administrative officers, drivers
22
23 and groundsmen. These non-clinical staff are often long-serving and knowledgeable. Their
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25 varying numbers across clinics may also help to explain the variability in the results
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27 presented.^{35,37}
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33 Given the high health care needs of Aboriginal and Torres Strait Islander populations living
34
35 in remote communities, and the importance of ensuring equitable access to high quality
36
37 primary health care, future research is warranted to explore whether and how the range of
38
39 factors postulated as possible explanations are indeed associated with the substantial
40
41 between-clinic variation in quality of primary care in remote clinics. The authors are
42
43 currently undertaking some of this work by examining whether similar patterns exist in
44
45 Aboriginal Community Controlled Health Services in the same jurisdiction and will be
46
47 updating analyses with NT Department of Health data to try and gain a better
48
49 understanding of the extent to which a range of factors identified as differentiating
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51 Indigenous Primary Health Care models from mainstream services, such as cultural safety,
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53 having a culturally appropriate and skilled Indigenous workforce and increased acceptability
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3 of the health service to community members are associated with variability in quality of
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5 care.^{38,39}
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10 11 **LIMITATIONS**

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14 This study relied on territory-wide, routinely collected data to test its hypotheses rather
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16 than collecting data prospectively using definitions and in formats that might have been
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18 optimal for the purpose. The routine collection is used to guide service delivery and is
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20 routinely reported at both NT and national levels. Its use for this study was not only guided
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22 by feasibility but also to demonstrate the wider utility of the collection. Nonetheless the use
23
24 of the existing collection contributed to both measurement noise and definitional
25
26 challenges which made underlying associations less evident. For example, the use of agency
27
28 nurses in NT DoH remote clinics are recorded either in payroll data or in expenditure data,
29
30 depending on the payment arrangements that NT DoH has with each nursing agency. For
31
32 this study agency nurses recorded in the NT DoH payroll were included in turnover and
33
34 stability figures, whereas work by agency nurses recorded in expenditure data were
35
36 included in the estimation of agency nurse proportion. A further limitation related to our
37
38 choice of workforce indicators. Given the dearth of literature describing health workforce
39
40 metrics specific to the Australian remote Aboriginal and Torres Strait Islander context, our
41
42 choice of health workforce indicators was guided by literature taken from the rural
43
44 Australian context.²⁷ The metrics we chose were unable to capture all important facets of
45
46 the remote health workforce, including, for example, employment of local Aboriginal staff.
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48 Our study used a selection of clinical indicators of quality of care. Other than the
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aforementioned employment stability indicators, no non-clinical indicators were used. Thus,

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3 even though it is recognised that characteristics such as culture, community participation
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5 and self-determination are important for providing high quality Indigenous primary health
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7 care services, indicators measuring these were not included. Additionally, no data were
8
9 available on the proportion of patients with cardiovascular disease on acetylsalicylic acid, so
10
11 even though measurement of this outcome was described in the study protocol, this
12
13 indicator was not used. A further limitation was that it was not possible to allocate staff
14
15 working in a supernumerary capacity in a remote health clinic to that clinic as this wasn't
16
17 recorded in the administrative records used. Finally, the research relates to a very specific
18
19 context of government-provided PHC in small, remote NT communities and the findings may
20
21 not be generalisable to other health systems, service models, geographical settings or study
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23 populations.
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30 **CONCLUSION**

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32 Overall, minimal evidence of the hypothesised negative effects of increased turnover,
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34 decreased stability and increased reliance on temporary staff on quality of care was found.
35
36 Substantial variations in clinic-specific estimates of association were evident, suggesting
37
38 that clinic-specific factors may counter any potential negative effects of decreased staff
39
40 employment stability. Investigation of clinic-specific factors using latent class analysis failed
41
42 to yield clinic characteristics that adequately explain between-clinic variation in
43
44 associations. Understanding the reasons for this variation would significantly aid the
45
46 provision of clinical care in remote Australia.
47
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56
57 technical assistance in accessing and interpreting departmental personnel, primary health
58
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1
2
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4
5 all staff working in the remote NT communities, particularly the clinic managers.
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7

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10
11 MPJ contributed to the design of the study and led analysis and drafting of the paper. JW
12
13 led the conceptualisation and overall study design and contributed to drafting the paper.
14
15 JSH contributed to the conceptualisation and design of the study and assisted with drafting
16
17 the manuscript. SG, YZ, MR and DJR contributed to the design of the study and assisted with
18
19 drafting the manuscript. All authors read and approved the final manuscript.
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30
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32
33 and reporting of this analysis.
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40 **Competing interests statement**

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42 None declared.
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47 **Patient consent for publication**

48
49 Not required.
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54 **Ethics approval**

55
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57
58 Territory Department of Health and Menzies School of Health Research (2015-2363).
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Provenance and peer review

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Data availability statement

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

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Table 1: Definitions of indicators measuring employment stability (main independent variables)

Measure	Definition
Turnover rate	$= \frac{\text{total number of exits}^{\dagger} \text{ in defined period}}{\text{average number of employees in defined period}}$
Stability rate	$= \frac{\text{Number of employees at start of defined period who remain employed at end of defined period}}{\text{Number of employees at start of defined period}}$
Agency nurse proportion	$= \frac{\text{Agency – employed nurse FTE}}{\text{Total FTE nurse positions}}$

FTE Full time equivalent

Table 2: Definitions of quality indicators (dependent variables)

Indicator name	Definition	Denominator Population	Source of data
<i>Child and maternal health</i>			
First antenatal visit	Number and proportion of regular clients who attended a first antenatal visit (at any health service locality) <ol style="list-style-type: none"> 1. Before 13 weeks gestation 2. At 20 weeks or more gestation 3. Any antenatal visit 	Resident women who gave birth to an Aboriginal or Torres Strait Islander baby	NT AHKPI
Fully immunised children	Number and proportion of Aboriginal or Torres Strait Islander children fully immunised at <ol style="list-style-type: none"> 1. 6 months to < 1 year 2. 1 year to <2 years 3. 2 years to <6 years 4. Any age and have received all age appropriate vaccinations 	Aboriginal or Torres Strait Islander resident children aged 6 months to <6 years	NT AHKPI
Anaemia test	Number and proportion of Aboriginal or Torres Strait Islander children who, in the past year have been tested for anaemia	Aboriginal or Torres Strait Islander resident children who are ≥ 6 months old and <5 years	NT AHKPI

Anaemia result	Number and proportion of Aboriginal or Torres Strait Islander children who, in the past year have been found to be anaemic	Aboriginal or Torres Strait Islander resident children who are ≥ 6 months old and < 5 years	NT AHKPI
Chronic Disease Management			
Glycated haemoglobin (HbA1c) test	Number and proportion of Aboriginal or Torres Strait Islander resident clients aged 15 years and over with Type 2 Diabetes Mellitus who have had a glycated haemoglobin (HbA1c) test in the past 12 months.	Aboriginal or Torres Strait Islander resident clients aged ≥ 15 years diagnosed with Type 2 Diabetes Mellitus	TLR
Glycated haemoglobin (HbA1c) result	Number and proportion of Aboriginal or Torres Strait Islander clients with Type 2 Diabetes Mellitus and whose most recent glycated haemoglobin (HbA1c) measurement within the past 12 months is $\leq 8\%$ (≤ 86 mmol/mol)	Aboriginal or Torres Strait Islander resident clients aged ≥ 15 years diagnosed with Type 2 Diabetes Mellitus and had glycated haemoglobin (HbA1c) tested	TLR
Angiotensin Converting Enzyme Inhibitor and/or Angiotensin Receptor Blocker	Number and proportion of Aboriginal or Torres Strait Islander clients with Type 2 Diabetes Mellitus with albuminuria who are on Angiotensin Converting Enzyme Inhibitor and/or an Angiotensin Receptor Blocker.	Aboriginal or Torres Strait Islander resident clients aged ≥ 15 years diagnosed with Type 2 Diabetes Mellitus and albuminuria	TLR

1 2 3 4 5 6 7 8 9 10 11 12	Non-smoking	Number and proportion of Aboriginal or Torres Strait Islander clients who are ex- or never smokers of cigarettes	Aboriginal or Torres Strait Islander residents aged ≥ 15 who have had their smoking status recorded	TLR
13 14	Preventive Health			
15 16 17 18 19 20 21 22 23 24 25 26 27 28	Pap smear tests	Number and proportion of eligible Aboriginal or Torres Strait Islander women who have had at least one Pap smear test during the last: <ol style="list-style-type: none"> 1. 2 years 2. 3 years 3. 5 years 	Aboriginal or Torres Strait Islander resident women aged 20-69 inclusive	NT AHKPI
29 30 31 32 33 34 35 36 37	Adult health check 15-55	Number and proportion of Aboriginal or Torres Strait Islander clients who have had a full adult health check.	Aboriginal or Torres Strait Islander resident clients aged 15 years to < 55 years	TLR
38 39 40 41 42 43 44	Adult health check 55+	Number and proportion of Aboriginal or Torres Strait Islander clients who have had a full adult health check.	Aboriginal or Torres Strait Islander resident clients aged ≥ 55 years	TLR

NTAHKPI Northern Territory Aboriginal Health Key Performance Indicator data

TLR Traffic light reports

Table 3. NT Department of Health clinics, characterised by staff employment stability indicators and quality indicators, 2011-2015

Characteristics	Mean	Standard Deviation	Minimum	Maximum	Number of clinics
Markers of staff employment stability					
Average annual head count	4.50	3.80	0.28	19.17	48
Turnover rate	0.07	0.03	0.00	0.18	48
Stability rate	0.40	0.14	0.00	0.77	48
Agency nurse proportion	0.16	0.09	0.00	0.42	48
<i>Quality indicators[†]</i>					
First antenatal visit (1. before 13 weeks' gestation)	0.49	0.16	0.17	0.96	47
First antenatal visit (2. at or before 20 weeks' gestation)	0.72	0.15	0.23	1.00	47
First antenatal visit (3. any antenatal care)	0.98	0.04	0.80	1.00	47
Fully immunised children (6-11 months)	0.88	0.08	0.63	1.00	47
Fully immunised children (12-23 months)	0.83	0.12	0.54	1.00	47
Fully immunised children (24-71 months)	0.80	0.08	0.58	0.935	47
Fully immunised children (any age)	0.81	0.08	0.60	0.93	47
Anaemia test	0.78	0.09	0.50	0.90	47
Anaemia result	0.17	0.05	0.06	0.30	47
Glycated haemoglobin (HbA1c) test	0.92	0.04	0.84	1.00	46
Glycated haemoglobin (HbA1c) result≤8%	0.48	0.10	0.23	0.71	47

Angiotensin Converting Enzyme Inhibitor and/or Angiotensin Receptor Blocker	0.84	0.10	0.59	1.00	46
Non-smoking	0.52	0.14	0.24	0.73	47
Adult health check 55+	0.34	0.12	0.09	0.72	47
Adult health check 15-54	0.42	0.15	0.11	0.75	47
Pap smear 2yrs	0.50	0.12	0.20	0.79	47
Pap smear 3yrs	0.40	0.07	0.18	0.55	47
Pap smear 5yrs	0.46	0.06	0.24	0.56	47

†One of the 48 health clinics did not independently report on any quality indicators during the study period. A second health clinic did not report on Glycated haemoglobin tests and Angiotensin Converting Enzyme Inhibitor and/or Angiotensin Receptor Blocker quality indicators.

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Table 4. Associations between markers of staff employment stability and quality indicators

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Indicator	Staffing measure	Slope ^A	95% Confidence Interval95% Confidence Interval		p-value	SD ^B
			Lower Limit	Upper Limit		
First antenatal visit (before 13 weeks' gestation)	Turnover	0.023	-0.010	0.056	0.2	0.33
	Agency nurse	-0.060	-0.178	0.059	0.3	1.03
	Stability	0.001	-0.113	0.115	>0.9	0.55
First antenatal visit (at or before 20 weeks' gestation)	Turnover	0.026	-0.018	0.070	0.3	0.27
	Agency nurse	-0.088	-0.231	0.056	0.2	1.10
	Stability	0.008	-0.091	0.107	0.9	0.44
First antenatal visit (any antenatal care)	Turnover	-0.001	-0.006	0.004	0.7	0.13
	Agency nurse	0.015	-0.028	0.058	0.5	0.38
	Stability	0.007	-0.015	0.030	0.5	0.27
Fully immunised children (6-11 months)	Turnover	-0.061	-0.119	-0.002	0.04	0.36
	Agency nurse	0.022	-0.135	0.179	0.8	1.21
	Stability	0.011	-0.073	0.095	0.8	0.51
Fully immunised children (12-23 months)	Turnover	-0.001	-0.017	0.015	0.9	0.16
	Agency nurse	-0.049	-0.155	0.057	0.4	0.63

	Stability	-0.017	-0.062	0.028	0.5	0.25
Fully immunised children (24-71 months)	Turnover	-0.012	-0.030	0.006	0.2	0.11
	Agency nurse	-0.056	-0.122	0.009	0.09	0.43
	Stability	0.002	-0.034	0.037	0.9	0.23
Fully immunised children (any age)	Turnover	0.002	-0.008	0.013	0.7	0.10
	Agency nurse	-0.061	-0.118	-0.005	0.03	0.38
	Stability	0.004	-0.025	0.033	0.8	0.19
Anaemia result	Turnover	0.011	-0.025	0.048	0.5	0.10
	Agency nurse	0.019	-0.055	0.093	0.6	0.62
	Stability	0.042	-0.008	0.092	0.1	0.24
Anaemia test	Turnover	0.017	0.000	0.034	0.06	0.11
	Agency nurse	0.023	-0.046	0.092	0.5	0.55
	Stability	0.002	-0.041	0.045	>0.9	0.32
Glycated haemoglobin (HbA1c) test	Turnover	-0.006	-0.024	0.012	0.5	0.11
	Agency nurse	-0.003	-0.076	0.070	0.9	0.57
	Stability	0.015	-0.015	0.044	0.3	0.20
Glycated haemoglobin (HbA1c) result	Turnover	-0.006	-0.022	0.010	0.5	0.24
	Agency nurse	0.037	-0.026	0.101	0.3	0.27
	Stability	-0.036	-0.066	-0.007	0.02	0.26
Angiotensin Converting Enzyme Inhibitor and/or	Turnover	-0.025	-0.060	0.010	0.2	0.24
Angiotensin Receptor Blocker	Agency nurse	0.053	-0.104	0.210	0.5	0.35
	Stability	0.044	-0.010	0.097	0.1	0.34
Non-smoking	Turnover	-0.007	-0.019	0.005	0.3	0.28

	Agency nurse	0.005	-0.043	0.053	0.8	0.28
	Stability	-0.005	-0.033	0.023	0.7	0.29
Adult health check aged 15-55	Turnover	0.031	-0.003	0.066	0.08	0.12
	Agency nurse	0.129	-0.036	0.294	0.1	0.59
	Stability	-0.056	-0.119	0.006	0.08	0.38
Adult health check aged 55+	Turnover	0.024	-0.040	0.087	0.5	0.21
	Agency nurse	0.265	0.073	0.457	0.007	1.01
	Stability	-0.027	-0.145	0.091	0.7	0.56
Pap smear 2yrs	Turnover	-0.007	-0.019	0.005	0.2	0.09
	Agency nurse	-0.058	-0.127	0.011	0.1	0.47
	Stability	0.006	-0.038	0.051	0.80	0.20
Pap smear 3yrs	Turnover	-0.021	-0.038	-0.004	0.01	0.18
	Agency nurse	-0.053	-0.137	0.030	0.20	0.73
	Stability	0.050	-0.030	0.130	0.20	0.51
Pap smear 5yrs	Turnover	-0.023	-0.041	-0.005	0.01	0.20
	Agency nurse	-0.048	-0.155	0.059	0.40	0.83
	Stability	0.057	-0.030	0.143	0.20	0.59

^ASlope= β coefficient

^BStandard deviation (SD) of clinic-specific estimates of association

Table 5. NT Department of Health clinic clusters, characterised by staff employment stability indicators, geographical remoteness and socio-economic disadvantage, 2011-2015

Cluster Number	Mean			Standard Deviation		
	1	2	3	1	2	3
Number of clinics	9	16	19	9	16	19
<i>^AAverage</i>						
Staff count	10.2	4.3	2.8	4.6	2.3	0.9
Staff exits	2.2	0.7	0.8	0.6	0.5	0.3
Turnover rate	0.2	0.2	0.3	0.1	0.1	0.1
Stability rate	0.5	0.6	0.4	0.1	0.1	0.1
Agency nurse proportion	0.2	0.2	0.2	0.1	0.1	0.1
<i>^BWithin-clinic standard deviation</i>						
Staff count	1.7	0.7	0.8	0.7	0.3	0.4
Staff exits	2.2	0.9	1.0	0.9	0.4	0.3
Turnover rate	0.2	0.2	0.4	0.1	0.1	0.1
Stability rate	0.1	0.2	0.3	0.1	0.1	0.1
Agency nurse proportion	0.1	0.1	0.2	0.1	0.1	0.1
<i>Time-invariant</i>						
Population (2015)	1391	505	338	1012	395	229
Index of Relative Socio-economic Advantage and Disadvantage	652	746	709	84	122	137
Google distance to Darwin or Alice Springs	313	267	332	222	167	220
Predominantly non-Aboriginal: % (count)	0.0	6.3	15.8	0	1	3

^ABased on calculating a single average per clinic over the recording period

^BBased on calculating a single standard deviation per clinic over the recording period

Table 6. Associations between NT Department of Health clinic clusters and quality indicators, 2011-2015

	Mean				Standard Deviation			
	Clusters (3)			Overall	Clusters (3)			Overall
	1	2	3		1	2	3	
First antenatal visit by 13 weeks	0.50	0.49	0.48	0.49	0.10	0.13	0.15	0.13
First antenatal visit by 20 weeks	0.74	0.75	0.70	0.72	0.06	0.14	0.15	0.14
First antenatal visit any time	0.98	0.98	0.98	0.98	0.01	0.06	0.03	0.04
Child immunisation 6-11m	0.86	0.90	0.89	0.89	0.07	0.08	0.07	0.08
Child immunisation 12-23m	0.84	0.84	0.87	0.85	0.10	0.12	0.11	0.11
Child immunisation 24-71m	0.82	0.78	0.81	0.80	0.09	0.09	0.07	0.08
Child immunisation (all)	0.83	0.80	0.82	0.81	0.08	0.09	0.06	0.08
Anaemia test	0.81	0.79	0.79	0.79	0.06	0.06	0.09	0.07
Anaemia result **	0.21	0.16	0.16	0.17	0.03	0.06	0.06	0.06
Glycated haemoglobin (HbA1c) test	0.90	0.93	0.93	0.92	0.04	0.04	0.04	0.04
Glycated haemoglobin (HbA1c) result	0.48	0.50	0.48	0.49	0.09	0.07	0.13	0.10
Angiotensin Converting Enzyme Inhibitor and/or Angiotensin Receptor Blocker**	0.74	0.84	0.88	0.84	0.11	0.05	0.08	0.09
Non-smoking	0.49	0.52	0.53	0.52	0.14	0.13	0.15	0.14
Adult health check aged 15-54	0.31	0.34	0.37	0.35	0.13	0.14	0.12	0.12
Adult health check aged 55+	0.45	0.45	0.38	0.42	0.15	0.15	0.16	0.15
Pap smear 2 years	0.51	0.52	0.50	0.51	0.12	0.10	0.12	0.11

	Mean				Standard Deviation			
	Clusters (3)			Overall	Clusters (3)			Overall
	1	2	3		1	2	3	
Pap smear 3 years	0.40	0.42	0.41	0.41	0.07	0.07	0.07	0.07
Pap smear 5 years	0.45	0.47	0.46	0.46	0.05	0.05	0.05	0.05

** p<0.001

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Table 7. Variation in mean associations between NT Department of Health clinic clusters and quality indicators, 2011-2015

Cluster	Stability			Turnover			Agency nurse %		
	1	2	3	1	2	3	1	2	3
First antenatal visit 13wks	0.176	-0.012	-0.110	-0.058	0.061	0.013	0.029	0.002	-0.289
First antenatal visit 20wks	0.180	0.065	-0.046	-0.020	0.023	-0.091	0.101	0.084	-0.261
First antenatal visit any	-0.050*	-0.113	0.054	-0.015	0.023	-0.038	-0.082	0.201	-0.018
Immunisation 6-11m	0.115	-0.181	0.026	-0.155	0.011	0.117	0.087	-0.263	0.304
Immunisation 12-23m	0.083	0.113	-0.079	0.002	0.012	0.039	0.075	-0.106	0.362
Immunisation 24-71m	0.114	0.107	-0.002	0.057	0.039	-0.005	-0.174	-0.303	-0.117
Immunisation overall	0.128	0.098	-0.008	0.031	0.034	-0.010	-0.106	-0.242	-0.016
Anaemia test	0.162	0.027	0.107	-0.000	0.008	-0.032	-0.050	0.034	0.050
Anaemia result	-0.011	-0.023	0.065	-0.016	-0.001	0.006	-0.032	0.118	0.142
Glycated haemoglobin (HbA1c) test	0.115	-0.467	0.152	0.311	0.050	-0.033	0.298	-0.392	-0.352
Glycated haemoglobin (HbA1c) result	-0.060	0.048	0.233	-0.078	0.014	0.039	-0.020	-0.183	-0.060
Angiotensin Converting Enzyme Inhibitor and/or Angiotensin Receptor Blocker	-1.048	-0.015	0.000	-0.615	-0.257	-0.046	0.298	-0.392	-0.352
Non-smoking	0.067	0.012	-0.017	0.024	0.037	-0.019	-0.021	0.002	0.122
Pap smear 2yrs	0.173*	-0.015	-0.016	-0.037	0.003	0.024	-0.086	-0.101	-0.061
Pap smear 3yrs	-0.331	-0.041	-0.012	-0.084	0.061	-0.052	-0.070	-0.382	0.054
Pap smear 5yrs	-0.371	-0.065	0.017	-0.086	0.061	-0.058	-0.031	-0.385	0.055

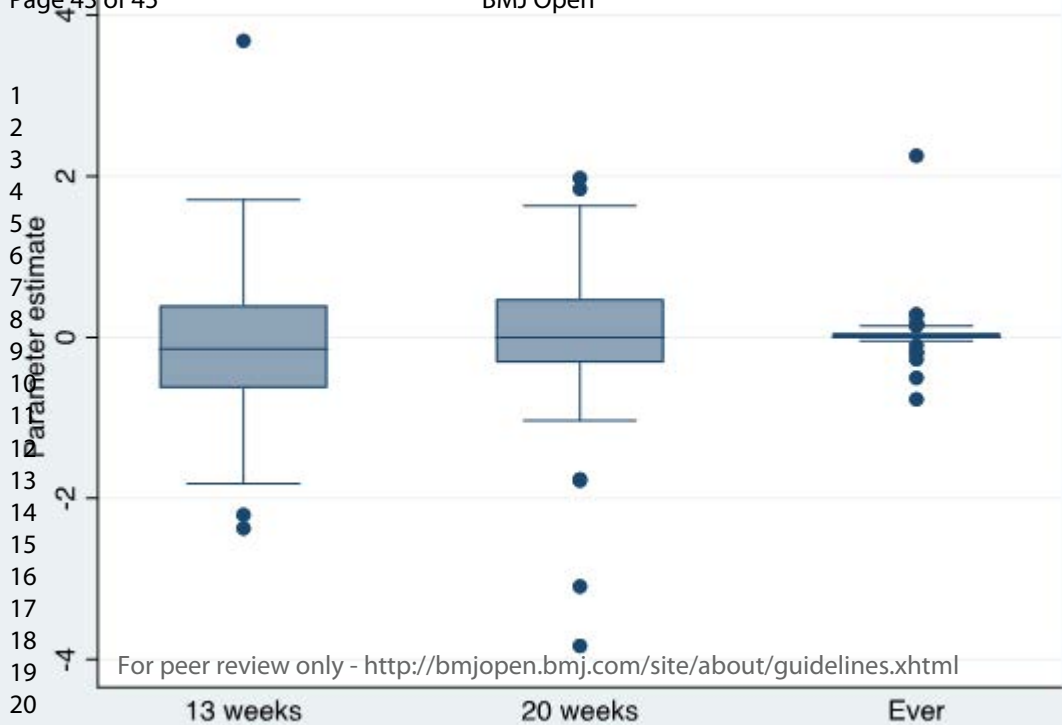
	Stability			Turnover			Agency nurse %		
Cluster	1	2	3	1	2	3	1	2	3
Adult health check 15-54	-0.220	-0.009	-0.229	-0.464	-0.278	-0.124	0.733	0.077	-0.098
Adult health check 55+	-0.478	0.218	-0.382	-0.403	-0.169	-0.126	2.825	0.310	0.315

* p<0.05

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3 **Figure 1. Distribution of clinic-specific associations between proportional use of agency**
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5 **nurses and antenatal care quality of care indicators**
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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	8
		(b) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-10
Bias	9	Describe any efforts to address potential sources of bias	10-11
Study size	10	Explain how the study size was arrived at	n/a
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-11
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	10-11
		(b) Describe any methods used to examine subgroups and interactions	10-11
		(c) Explain how missing data were addressed	See comment beneath Table 3
		(d) If applicable, explain how loss to follow-up was addressed	n/a
		(e) Describe any sensitivity analyses	n/a

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Table 3 (numbers of participating health services)
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 5, reported by clinic clusters
		(b) Indicate number of participants with missing data for each variable of interest	Table 3
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	n/a – time course is summarized in analysis
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a – relevant confounders not established
		(b) Report category boundaries when continuous variables were categorized	n/a
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Table 5
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-16
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18-19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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3 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE
4 checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at
5 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.
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