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Regional disparities in apprentice attrition rates: heat and quarter four's significance in northern Australia

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Abstract

Apprenticeship completion rates have remained persistently low for decades in spite of broad agreement over the causes of non-completions. A possible factor missing from these explanations is climate, particularly in northern Australia where traditional trade apprentices are exposed to extreme conditions and exert themselves. We hypothesise that: the onset of hotter, more humid weather in northern Australia during the fourth quarter of the calendar year would be reflected by an increase in trades' apprenticeship withdrawals and cancellations. Using the entire National Apprentice and Trainee Collection, completion and attrition data was geographically categorised into north and south Australia. Statistical

analyses identified a clear difference in trade occupation's cancellations and withdrawals. Regionally specific climate variables are briefly examined, further supporting the claim that heat stress appears a likely contributor. These cross-disciplinary findings have a broader significance as apprenticeship completions contribute to socio-economic growth and the public policy agenda of northern development.

Introduction

The long-held desire of the Australian settler state to develop the north of the country (Hasluck, 1956) has recently been re-invigorated by the publication of a *White Paper on Developing Northern Australia* (Australian Government, 2015). An enduring feature of economic development proposals for the half of the continent above of the Tropic of Capricorn has been the call for a much larger resident population with the appropriate skills and endurance to work productively in the harsh climatic conditions (Australian Government, 2015; Brown, 1961; Price, 1954). Vocational education and training is a key policy area supporting population growth, skills development and regional growth, particularly through enrolling students in the apprenticeship and traineeship system in order to obtain nationally recognised qualifications that enable economic participation. This article reports on the results of a research project that sought to identify whether northern Australia has experienced any unique contributing factors to apprenticeship attrition rates related to climatic conditions.

Apprentices and trainees in designated occupations must register with state and territory-based training authorities and submit to a contract of training that complies with legislative and regulatory requirements. Successful completion enables them to obtain a formal qualification recognising their skills and competence which equips them for employment in their specialist field. While some nontrade traineeship contracts can be completed in less than

one year, the more traditional trade vocations can take four years or longer to complete. Commencements describe the lodging of the contract of training whereas withdrawals (within the probation period) and cancellations occur prior to the completion of the contract (National Centre for Vocational Education Research, 2014, p. 17). Records of this information have been kept in a nationally consistent format since mid-1994 by the National Centre for Vocational Education Research (NCVER).

Despite large numbers of students entering into traineeships and apprenticeships, there have been high rates of non-completion. Contract finishing rates for those commencing in 2011 were just 46.2 per cent for trade occupations and 56.3 per cent for non-trades (National Centre for Vocational Education Research, 2016, p. 5). For the trades, this rate is little changed from the 45.8 per cent completion rate for those who commenced in 2004 (National Centre for Vocational Education Research, 2010, p. 1). Since 1994 nearly 860,000 persons have withdrawn from or cancelled a contract of training in the trade occupations nationally with a peak of 58,100 in 2015 (National Centre for Vocational Education Research, 2015, table 9). Such figures have resulted in multiple reviews of the training system to address persistent stakeholder concerns of public resource wastage and increased costs to employers of apprentices due to high rates of non-completion (Australian Workforce and Productivity Agency, 2013, p. 118; McDowell et al., 2011, p. 9).

The provision of ‘a northern workforce for growth’ was one of six key areas identified as essential to supporting an economically stronger region in the White Paper on developing northern Australia (Australian Government, 2015, p. 102). The occupations that dominate the northern labour market reflect its industry structure; approximately 40 per cent are employed as technicians, trade workers, machine operators, drivers and labourers which is ‘well above the national average of around 30 per cent’ with a corresponding reduction in non-trade jobs

such as professionals, sales workers, clerks and administrators (Australian Government, 2015, p. 103). The White Paper describes a range of challenges to further growing the northern workforce. These include taxation, remoteness from family, lack of social/cultural amenities and relocation costs (Australian Government, 2015, pp. 104-105).

This northern development agenda has been a periodic theme in Australian national politics since European settlement (Dale, 2013; Davidson, 1972). However, another recurring narrative has been the climatic unsuitability of northern Australia for settlement and heavy labour (G. Buchanan, 1925; Price, 1954; Zander, Surjan, & Garnett, 2016), given its hot conditions for approximately half of the calendar year which are progressively exacerbated by increased humidity in the far north rendering conditions very uncomfortable. In the Tropical Monsoon region, which roughly corresponds with the 'Hot humid summer' zone in Figure 1, these conditions occur between about October and March during the 'Wet Season' (Bureau of Meteorology, 2016). The colloquially termed 'build up' months of October to December produce elevated temperatures and humidity while the cooling effect of rainfall is scarce, and to a lesser extent, in the monsoon period from December to March when high humidity and temperatures are cooled by localized tropical downpours or longer periods of monsoonal rain (Moise et al., 2015). In the interior, the humidity gives way to intense dry heat in the summer months (Brearley, Harrington, Lee, & Taylor, 2015). The arid zones of northern Australia also demonstrate extremes of standard weather indicators such as temperature and humidity that also present worksite challenges to personal comfort (Stafford Smith & Huigen, 2010, p. 6). Such consistently hot conditions – either as extreme temperatures or combined high temperatures and high humidity, are widely considered to be deleterious to labour-intensive and outdoor work (Mitchell et al., 1976; Singh, Hanna, & Kjellstrom, 2015).

[Figure one near here]

Figure 1: Australian climate zones based on temperature and humidity; http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp?maptype=kpngrp *(Australian Government Bureau of Meteorology, 2016).*

Given the historical and empirical recognition of these environments as extreme, it is notable that the White Paper makes no significant reference to the climatic conditions of northern Australia as a potential factor influencing the workforce that will be responsible for its rapid development. Similarly, *The Demography of Developing Northern Australia* (Taylor, Payer, & Brokensha, 2015, p. 1), a comprehensive study of the population dynamics required to achieve the White Paper's ambitious goal of increasing the current population from about 1.3 million to a target of between 4 and 5 million residents by 2060, does not mention the potential influence of climate.

Northern Australia's climatic conditions in general are also omitted from national and regional studies of apprentice and trainee completion rates. In her analysis of the national 2008 and 2010 *Apprentice and Trainee Destination Survey* results for trade apprentices (1,700 completers and 1,500 non-completers), Bednarz (2014, p. 13) identified 16 main reasons for not completing an apprenticeship. Climate was not specifically referred to, although the 'poor working conditions' mentioned by 3.1 per cent of respondents in each year might include such environmental factors. Bednarz (2014, p. 15) describes an additional three studies that draw broadly similar conclusions. Coming from a more localised perspective and using data from the state of Victoria only, the Victorian Auditor-General (2014) identified no less than eight state-based reviews that touched upon apprenticeship completions and summarised the major contributors to cancellations as bullying, harassment, job

circumstances and lack of support at key stages of the apprenticeship. Again, climate-related factors were not identified.

These more recent works supported the findings from 437 interviews with apprentices, trainees, employers and trainers to determine the major factors that contributed to retention and completion (Harris, Simons, Symons, & Clayton, 2001, pp. 224-226). That study explored and found support for 15 negative influences on retention, each of which was included in the aforementioned work of Bednarz and, similarly, no mention of climate was made. It may be significant that no one from the three jurisdictions that comprise northern Australia (Western Australia, Queensland or the Northern Territory), was interviewed in this study. Therefore, all of the responses came from Australian regions south of the Tropic of Capricorn where the majority of the population is located in the temperate climatic region shown in Figure 1 that is characterised by dry mild/warm summers and cool winters (Bureau of Meteorology, 2016).

Historical accounts of the physical and psychological discomfort of the monsoonal north have been recently complemented by an emerging literature on climatic heat stress in the region. With hot and seasonally humid conditions, occupational heat stress appears to be the product of work rate (bodily heat production) and work clothing (physical barrier to heat dissipation). With extensive military operations in Northern Australia, soldiers have experienced substantial heat stress during self-paced and set-paced work (Amos, Hansen, Lau, & Michalski, 2000; Cotter, Roberts, Amos, Lau, & Prigg, 2000). With similar protective attire and the impost of carrying equipment and limited ability to select workload, Northern Australia firefighters also suffer rapid and sustained elevation of core temperature (Brearley, 2016; Brearley, Norton, Trewin, & Mitchell, 2011). Less physiological perturbation has been reported for miners (Peiffer & Abbiss, 2013), medical responders (Brearley, Heaney, &

Norton, 2013) and electrical utility workers (Brearley et al., 2015), although the cumulative impost of elevated core temperature may contribute to heat stress symptoms that include headaches, nausea, muscle cramps, dizziness, irritability and skin rashes (Brearley, personal communication 12 November 2016).

(Oppermann, Spencer, & Brearley, 2015) also explored the complexity of how heat stress is understood in the region and how it might undermine safety, productivity, health and wellbeing in outdoor labour intensive roles, with negative implications for the northern development agenda. Most recently, (Jia, Loosemore, Gilbert, & Rowlinson, 2016) have reported on an ethnographic study of workers from a major construction project in Northern Australia, in which heat stress as a result of exposure to hot and humid conditions during the 'build up' of 2015 demonstrated significant effects on productivity, health and safety.

If Northern Australia climatic conditions contributed to apprenticeship cancellations and withdrawals, trade apprentices are most likely to be impacted due to their outdoor exposure and/or non-air-conditioned worksites. Thus a cross-disciplinary hypothesis was developed: that the onset of hotter, more humid weather in northern Australia during the fourth quarter of the calendar year will be reflected by an increase in trade apprenticeship and traineeship withdrawals and cancellations.

Material and methods

Data acquisition

Following a request from the authors in July 2016, NCVER emailed an Excel spreadsheet with the specified data from the National Apprentice and Trainee Collection for the period 1 July 1994 to 31 December 2015 on the total national cohort of apprentices and trainees enumerating commencements of a contract of training, withdrawals from training and

cancellations of contracts (personal communication, 17 August 2016). Commencements were assigned to a quarter of the year based on the date the contract of training is registered or approved under the provisions of the relevant state/territory legislation (National Centre for Vocational Education Research, 2014, p. 17). The data was produced in 'raw' form; i.e., without seasonal adjustment (Australian Bureau of Statistics, 2008) for each quarter of the calendar year, with quarter one encompassing January through March, quarter two April through June and so forth. All references to the raw data and subsequent analysis used in this paper are drawn from this specifically commissioned data extraction.

Geographical stratification

The raw data was geographically categorised into north and south based upon the description used in the white paper on developing northern Australia (Australian Government, 2015, p. 108) that defines the area as the entire the Northern Territory and those portions of Western Australia and Queensland that lie above the Tropic of Capricorn (Figure 2).

[Figure two near here.]

Figure 2: Northern Australia as defined in the White Paper on northern development.

A best fit division into north and south was undertaken by using postcode districts and mapping their alignment with reference to the Australian Bureau of Statistics postcode concordances at Statistical Local Area level in 2006 and the smaller Statistical Areas Level 2 in 2011 (Figure 3). While not a perfect fit with the Tropic of Capricorn, many of the areas that overlap the boundary are sparsely populated and considered to be of little relevance given the overall sample size. In fact, only the postcode 0872 significantly moved to the south of the northern development line. That district includes the southern part of the Northern Territory which is included already in the northern Australia definition and the

north of South Australia and the central east of Western Australia - both districts with very few residents. It is likely that in any given year these areas outside the Northern Territory would have few or no commencements, withdrawals or cancellations. Despite these minor limitations, the postcodes provide a consistent data element in the National Apprentice and Trainee Collection for the entire time period whereas the national census has used different geographical boundaries at different times as noted above. The postcode analysis was supplied to NCVER by the authors and was used to identify the geographical location of the place of employment of the apprentices and trainees.

[Figure 3 near here].

Figure 3: Post code division into northern (unshaded) and southern (shaded) Australia. Some areas are excluded, e.g. southwestern Tasmania, as they are in an unallocated delivery area postcode that frequently encompass national parks and wilderness areas. (Image courtesy of Huw Brokensha, Charles Darwin University. Created using ABS digital boundaries, Cat. No. 1270.0.55.003 in ArcGIS).

The raw data furnished by NCVER (2016, p. 4) is comprised of: counts, where the data sets are complete; the Centre's standard estimates for the final seven quarters in the time series for cancellations and withdrawals; and estimates for the final three quarters of commencements. The estimation process is based on quarterly reporting that is consolidated annually, with recent activity levels estimated by weighting recently processed numbers based upon average reporting lags. This data extraction recorded a total count/estimate of more than 4.81 million contracts of training that commenced during the 21 year period and 2.18 million cancellations and withdrawals (table one).

The national total number of cancellations and withdrawals represented approximately 45 per cent of all commencements. This compares favourably with the most recent complete data set

on attrition rates for apprentices and trainees from 2011 which indicates that contract completion rates were 53 per cent for all occupations and individual completion rates (which take into account recommencements) were 58.3 per cent for all occupations (National Centre for Vocational Education Research, 2016, p. 5). Group Training Organisations and Apprentice Support Centres (personal communication) indicate that most cancellations and withdrawals are initiated by the person in training rather than the employer.

Trade stratification

Following geographical stratification, the data was separated into trade and nontrade occupational groups according the classification of 'Major Groups' of similar occupations based on the Australian Bureau of Statistics' *Australian and New Zealand Standard Classification of Occupations (ANZSCO) - First edition, revision 1, ABS cat.no.1220.0* (National Centre for Vocational Education Research, 2014, p. 17). Nontrades are defined as Major Groups one, two and four through eight, while trades are defined as all of Major Group three (technicians and trades workers) and back cast by the NCVER to 1994 for consistency. In general terms, the trades represent many of the occupations that are labour-intensive and frequently involve working outdoors or in non-air-conditioned workplaces including electricians, plumbers, mechanics and construction workers. Nontrade occupations include retail, clerical, administration and managerial positions that tend work indoors. Given that some nontrade apprentices and trainees may also work outdoors, it is possible that the impact of climate may be understated.

[Table one near here.]

Table one: Commencements, cancellations/withdrawals by trade and nontrade divided into regions.

Statistical analysis

If the hypothesis of increased attrition for trade apprentices related to exposure to hot and/or humid working conditions that start in quarter four (October to December) was correct, a seasonal pattern would be evident. In order to examine the timing of commencements and cancellations/withdrawals, an analysis of the following categories (table two) was conducted for each calendar quarter.

[Table two near here.]

Table two: Apprentice and trainee stratifications

Testing for seasonal, calendar-related movements is an appropriate technique to determine if there is a significant difference between the northern and southern regions. Seasonality effects are reasonably stable with respect to timing, direction and magnitude. They include 'weather fluctuations that are representative of the season' and can also be related to social and cultural behaviour such as the start and end of school terms (Australian Bureau of Statistics, 2008).

Most Australian apprentice and trainee analytic reports contain seasonally adjusted data as unadjusted flow series can conceal true underlying movement in the time series due to the different scheduling of holidays such as Easter or other events. For example, analysis of the impact of the global financial crisis in 2008-2009 on apprenticeship and trainee commencement, completion and eventual employment required extensive seasonal adjustment to reveal specific patterns during the economic downturn (Karmel & Oliver, 2011, p. 11). However, for this research project it is the very pattern of seasonality that is being interrogated. As such, these standard adjustments were not applied.

Auto-Regressive Integrated Moving Average (ARIMA) model

An ARIMA analysis additive time series evaluation was applied to all eight categories of data (table two) to determine if non-random seasonality was present in the quarterly observations. This was done at the 'first differences' level that compared the difference between two adjacent time periods in order to remove the trends observed in the raw data while the overall process makes the series stationary, that is, the series varies around a constant mean level. This process of trend 'flattening' allowed for meaningful comparisons over long periods of time to establish whether something other than random events, such as seasonality, was represented in the data.

The results from the ARIMA are presented in table five. The correlation figures in table three give an indication of the presence of seasonality with larger numbers indicating greater seasonality and smaller numbers suggesting more random behaviour.

[Table Three near here.]

Table three: ARIMA correlations and seasonality descriptors.

Generalised Linear Model (GLM)

In order to further explore a possible seasonal effect of the quarters related to trade cancellations and withdrawals, a GLM test was applied to the eight stratifications to determine which quarters significantly contributed in the observed seasonality reported in table five.

Specifically, each GLM procedure could provide further confirmation of the original ARIMA measures of seasonality by examining the significance of each quarter's contribution against the other three quarters in each calendar year. LSMEAN is a calculation in the GLM process and stands for the 'least square mean' which computes the effect of a variable, in our case commencements or the combined cancellation/withdrawals (table one), in each quarter over

the entire 21 year period. LSMEANs are predicted population means; they estimate the marginal means over a balanced population. The population is considered to be balanced if both groups have effects that are estimated with equal precision. This test indicated the relative impact made by each quarter to any observed seasonality. The significance of quarter four trade cancellations and withdrawals contributing to seasonality compared to remaining quarters was identified by $p<0.05$.

While GLM calculations were completed for all eight stratifications (table two), for the purposes of testing the working hypothesis only four results were required to demonstrate the findings regarding seasonality: examples of very strong seasonality (north and south trade commencements), no seasonality (south trade cancellations/withdrawals) and strong seasonality (north trade cancellations/withdrawals). The final two directly compare north and south regions on the basis of cancellations and withdrawals.

Calculations and results

Despite the ARIMA test indicating a difference in the seasonality of nontrade commencements between the northern and southern regions of Australia, that relationship was not investigated further as it is outside the scope of this project. Likewise, nontrade cancellations and withdrawals have not received further consideration as they were very similar for both the north and the south in that they display some seasonality but without a distinct pattern emerging in either region. While the results from these categories are still reported for comparison purposes, the remainder of this article is focused upon the analysis of apprenticeships in trade occupations in the northern and southern regions.

Raw data/frequency analysis

Table one summarises the commencements, cancellations and withdrawals during the examined period. Northern Australia accounted for 5.9 per cent of total national apprentice

and trainee commencements in the combined trades and nontrades. In percentage terms, raw cancellations and withdrawals in northern Australia reflect the region's national share of the population (Taylor et al., 2015, p. 3).

Both north and south nontrade cancellations/withdrawals steadily increased from 1994-2012 followed by a dramatic reduction and continued downward trend to the end of 2015. In 2012, the Australian Government withdrew traineeship incentive payments to employers resulting in national cancellations and withdrawals demonstrating a dramatic decline in the second half of that year. Trade commencements steadily increased from 1994 until 2011 in the south when they have plateaued at around 83,000 per year until a clear downward trend emerged in 2014 and 2015. Similarly, northern trade commencements also steadily increased from 1994 until 2013. A trend of decline became evident in 2014 and 2015 with commencements dropping from over 7,000 in 2012 to less than 6,000 in 2014 and just under 5,000 in 2015. Both north and south trade cancellations and withdrawals, not unexpectedly, followed the trends demonstrated in commencements.

The counts presented in table four represent the quarter of the greatest frequency of commencements and cancellations/withdrawals, respectively, by trade and nontrade occupation and region.

[Table four near here.]

Table four: The quarter representing the highest frequency of commencements and cancellations/withdrawals sorted by regional and occupational stratification by calendar quarter.

The raw data suggests a nationally consistent pattern of seasonality with high levels of trade commencements in quarter one, a different pattern of seasonality in nontrade commencements between north and south in addition to a clumping of activity in all areas

measured in quarters one and four. Trade commencements are identical in both north and south with the largest number of contracts of training lodged at the start of each year. This preliminary investigation of the raw data suggests that there is a difference between the north and south in terms of trade cancellations and withdrawals.

ARIMA calculations

As a result of 'flattening' the long-term trends present in the time series and making the means 'stationary', correlation data can be calculated to more accurately describe the patterns observed in the raw data (table four).

[Table five near here.]

Table five: summary of the ARIMA evaluation north/south, trade/nontrade commencements and cancellations/withdrawals on a quarterly basis. Data are correlation coefficient (standard error).

As demonstrated in the raw data, both the north and the south trade commencements indicated very strong seasonality with large numbers grouped in quarter one. Less obvious from the raw data, having been masked by the trends, is the significant difference between the north and the south in trade cancellations/withdrawals with the latter demonstrating the least seasonality of the eight fields that were investigated. The seasonality in northern Australia for trade cancellations and withdrawals identified through ARIMA time series analysis is not replicated in the south, even though commencement patterns were very similar with the large observed number of contracts issued in quarter one of each year as confirmed by the ARIMA analysis.

GLM calculations

The GLM test reported in table six shows that the southern pattern of commencements observed in the raw data is strongly driven by each quarter with the exception of quarter three (July to September) and as expected on the basis of the ARIMA test, table five also demonstrates a similar seasonality outcome for north trade commencements. Commencements were highly seasonal and appear to have become consistently predictable in both geographical regions.

[Table six near here.]

Table six: The significance (p value) of quarter four trade cancellations and withdrawals contributing to seasonality compared to remaining quarters. . Least Squares Means for effect calendar period Pr > [t] for HO: LSMean (i) = LSMean (j) Dependent Variable: diff1. The significance level, Pr > |t|, is the probability of getting a larger value of t if the parameter is truly equal to zero. A very small value for this probability leads to the conclusion that the independent variable contributes significantly to the model.

This GLM test of southern Australian cancellations and withdrawals shows no strong relationships between the quarters, therefore, further supporting the original inability to distinguish an obvious pattern in the raw data and the ARIMA analysis's calculated absence of seasonality. Conversely, there is clear and significant seasonality in cancellations and withdrawals in the trade occupations in northern Australia that is not observed in the south when the trends are removed. There, quarter four makes a highly significant contribution to trade cancellations and withdrawals compared to the other three calendar quarters.

Trade commencements in both the northern and southern Australia indicated quarters one, two and four contributed to seasonality in both cases. While the raw numbers of those in training differs due to the distribution of the national population, both the trend lines and patterns of trade commencements in the sparsely settled north essentially duplicated those found in the more populous south. Group Training Organisations and Apprentice Support

Centres (personal communication) report that commencements are heavily influenced by the schedules and blocks of training providers and conversely, did not believe that off-the job training influenced decisions related to attrition. Trade apprentices commence their training and introduction to their chosen vocation in statistically similar patterns regardless of their work location. Equally, they experience non-completion rates that are approximately similar and slightly greater than their share of the national population (table one). However, there is a clear distinction between the northern and southern regions in relation to the timing of non-completions with quarter four emerging as significant in the north of the country.

Discussion

These results point to an unambiguous point of difference in the timing of apprentices withdrawing from or cancelling their training contracts between northern and southern Australia. Until now, this phenomenon has not been visible to vocational education and training policy analysts that have used the NCVER data that had been analysed at state and territory jurisdiction level. The pattern of cancellations and withdrawals in trade occupations is unique to northern Australia. However, it is recognised that the relationship described in these results is by association rather than causal, requiring further research to identify contributors to the aforementioned seasonality.

Seasonality has been recognised by the Northern Territory Government as one of the factors that impacts on an employer's decision to engage an apprentice or trainee in the jurisdiction. While the Wet Season is recognised as negatively influencing productivity, such effects are generally attributed to site or road closures and to high winds, cyclones, heavy rains or flooding (Northern Territory Department of Employment, 2006, p. 29). While these events can occur throughout the Wet Season, cyclones occur infrequently and at irregular times (Ramsay, Leslie, Lamb, Richman, & Leplastrier, 2008, p. 1085) and would therefore be

unlikely to substantially contribute to the seasonality of quarter four cancellations and withdrawals over the 21-year period. Furthermore, heavy rains are more prevalent after the onset of the active monsoon, usually between November and April (Pope, Jakob, & Reeder, 2009, p. 6699), which, from a climatic basis alone, would tend to support predictions of similar or greater levels of cancellations and withdrawals in quarter one when compared to quarter four.

Other climatic factors are more likely to contribute to cessation of trade apprenticeships. Subjective responses of northern Australian outdoor workers following the 2015/16 Wet Season (quarter four 2015 and quarter one 2016) identify heat as a chronic impact upon productivity (Brearley, personal communication, 14 November 2016). Specifically, approximately 70% of those workers reported heat impacting the speed of task completion on a daily or weekly basis, while only ~15% reported heat impacting the quality of work completed.

Moderating work rate is a heat stress mitigation strategy, lowering bodily heat production where a high environmental heat load exists, such as during hot and humid weather. While this approach compensates for the narrow gradient temperature between the skin surface and environment, it is generally initiated upon feeling warm to hot and uncomfortable (Schlader, Simmons, Stannard, & Mündel, 2011). Both the results of occupational surveys and monitoring of workers confirm that exposure to hot conditions produces perceptions of elevated body temperature and thermal discomfort (Brearley et al., 2015). While the long-term impact of heat exposure on vocational choice remains to be reported, chronic exposure to heat confers physiological and perceptual adaptations, a process known as heat acclimatisation. Such adaptations are considered to mitigate heat stress (Brearley, 2016), as undertaking work at a fixed intensity in a laboratory results in less physiological perturbation

following completion of a structured heat acclimatisation program (Lorenzo, Halliwill, Sawka, & Minson, 2010). Yet in a field occupational setting, heat acclimatised workers demonstrate similar perceptions of body temperature to non-heat acclimatised, albeit at significantly higher core temperatures (Brearley et al., in press).

As such, northern-based apprentices are likely to be heat acclimatised, particularly during quarters one and four, such adaptations do not prevent reporting of chronic heat stress symptoms that include headaches, nausea and irritability as well as the more severe symptoms of low coordination, confusion, vomiting and fainting. In fact, workers predominantly exposed to outdoor and or full sun conditions are 2.5 to 2.9 times more likely to report heat stress symptoms compared to those workers predominantly exposed to air conditioning and therefore, a cooler work climate, who are five times less likely to report chronic and/or severe heat stress symptoms (Brearley, personal communication, 16 November 2016). Such findings support the hypothesis that apprentices in the trades may be making decisions about their employment on the basis of perceptions of heat stress.

Employment, retention and completion figures may be shaped by additional factors operating in isolation or in combination with heat and a range of other climatic drivers identified above. Business closedowns for the Christmas holiday period, the weight on businesses of holiday pay without profit-producing work and the Wet Season employment lull in industries such as tourism, hospitality and primary production may all shape the employers' willingness to discontinue apprenticeship contracts. However, as yet there is no published data to indicate whether this seasonality contributes to the attrition rates observed in the trades. Further research on these potential drivers and the role of heat stress is needed in the region.

The wider literature on the adaptation to environmental hazards provides some avenues of exploration. One strategy identified in response to environmental heat is 'migration,

either temporary or permanent avoidance of particular stress conditions' (Auliciems, 1997, p. 156). It is possible that withdrawals or cancellations of apprenticeships in the trades could be interpreted as adaptations or responses to heat stress given the concentration of withdrawals and cancellations in the 'build up' period. Supporting this conclusion are the findings of a nation-wide study of over 1,250 persons who had experienced heat stress. Those residing in northern Australia had an 86 per cent higher probability of intending to move because of heat than a person from southern Australia (Zander et al., 2016, p. 302).

Occupational exposure was not explicitly reported in this survey, and environmental heat was combined with other reasons for moving residence, including family proximity, relationships, social support and employment prospects. However, previous studies indicated an individual's stated intention to move because of heat could be related to employment in outdoors labour-intensive occupations such as construction, mining and agriculture (Zander et al., 2016, pp. 303-304). Apart from agriculture, trade apprenticeships are part of the employment mix of these industry sectors, and with such a high proportion of the general population finding heat a factor in their intention to move, it seems reasonable to expect greater relevance of this factor to trade apprentices who not only live, but also work in, those same conditions.

Nonetheless, the combination of thermal physiology research and the clear preference of the general population represented in the Zander, et al. (2016) survey begs the question of why environmental conditions in general, and heat in particular, are absent from the analysis of vocational training data. In the occupational space more broadly, there is also the consideration that heat stress is filtered through governance rationales that occlude the occurrence and effects of heat stress on productivity, health and wellbeing (Oppermann et al.,

2015). Different accounts of environmental conditions and their significance as well as highly lucrative wages and contracts that reward ‘on time’ completion of major projects may obscure heat stress and its active management. The result is that in the northern Australian workplace, heat stress has not been acknowledged as a problem that extends beyond formal work health and safety policies to broader issues of productivity, retention and wellbeing (Oppermann et al., 2015, p. 38).

Jia and Loosemore et al. (2016) explore this issue in more depth identifying how heat stress management falls through a gap between understanding heat in terms of two competing institutional logics in occupation settings: one of productivity and the other of safety. The epistemological, cultural, social and economic difficulties of articulating and acting on heat stress in the workplace may therefore contribute to the absence of readily available and acceptable ways of articulating its role in attrition rates in general and its effects on apprentices completions in particular.

Identifying the cause of apprentice attrition in quarter four is essential. If the heat stress hypothesis is correct, its significance is heightened by two further trends. One of these is the economic development of northern Australia, which currently relies heavily upon the trade occupations that frequently work outdoors. This skewing of the northern workforce towards the trades is predicted to increase, with a corresponding need to address any drivers of non-completions of apprenticeships, as it is currently assumed completions will occur and bring both economic and social benefits to apprentices, employers and society in general (J. Buchanan, Raffaele, Glozier, & Kanagaratnam, 2016, p. 23).

The second trend is much more profound in its depth, duration and complexity – the effect of observed and anticipated climatic change, which has already caused significant warming in northern Australia (Bureau of Meteorology & CSIRO, 2016). It is worth recalling a relatively

early discussion of climate impacts in Australia, in which the National Health and Medical Research Council noted ‘a significant potential for workers to experience heat stress if there is a significant rise in either temperature or humidity’ (Evans, Bryant, & Calvert, 1990, p. 24) and which also designated outdoor occupations as the most dangerous in this context (Evans, Bryant et al. 1990, p. 24).

Conclusion

Given that heat stress has been shown to be relatively invisible in workplaces and that the vocational education and training system's policy deliberations do not consider climatic impacts, we have speculated that heat stress might be a contributor to increased trade cancellations and withdrawals in quarter four in northern Australia. This conjecture is supported by the time series analysis of a very large cohort over an extended period. Further verification for the working hypothesis could come from qualitative investigations conducted with employers and trade apprentices in their workplaces to examine whether and to what extent heat stress might impact on the decision not to complete a contract of training.

This cross-disciplinary investigation has demonstrated an unambiguous point of difference in completions between northern and southern Australia. There is an observed seasonality of cancellations and withdrawals in trade occupations in northern Australia that are clearly regional in nature. Until now, this has not been made visible in NCVER data by vocational education and training policy analysts. The correlation between quarter four's hot/humid climatic conditions and increased cancellations and withdrawals in the region has been hypothesised as a key reason for the spike of non-completions, but it may combine in complex ways with other social and economic drivers of employment, retention and completion practices.

Identifying governance rationales or institutional logics, visible in workplace practices including as responses to climatic conditions, are some of the ways of unpicking the lived realities behind the data. As such, focusing upon national training system policy interventions, regional economic development or human physiological studies in isolation may not expose some of the more complex reasons for cancellations and withdrawals. This could be remedied by using a broader cross-disciplinary analysis to identify whether heat stress – or indeed any other factor – plays a role in trade apprenticeship completion rates. This more comprehensive examination of non-completions might offer alternative points of departure for interventions in the apprenticeship system in northern Australia, and perhaps beyond.

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