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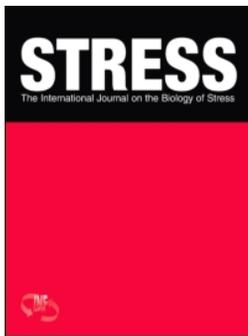
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Elevated Levels of Hair Cortisol Concentrations in Professional Dementia Caregivers

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Abstract

Providing care for people with dementia can be a highly stressful profession. Hair Cortisol Concentration (HCC) levels have been used as a biological marker for HPA axis activity to demonstrate that informal caregivers of people with dementia could be vulnerable to chronic stress. The current study aimed to progress the findings of research conducted with informal caregivers and is the first study to assess HCC as biological indicator of stress in professional carers of people dementia. HCC levels were compared between 32 professional dementia caregivers (30 females with a mean age of 45.83 and 2 males with a mean age of 24.50), 45 employees working in higher education settings (42 females with a mean age of 38.66 and 3 males with a mean age of 31.89) and 88 undergraduate students (67 females with a mean age of 24.04 and 21 males with a mean age of 23.91). Analysis of HCC was used to assess HPA axis activity over a 1-month period. A one-way ANCOVA, with age and gender being included as covariates, revealed that higher levels of HCC were observed in professional dementia carers than people who worked within higher education settings and undergraduate students. The results indicated that professional dementia caregivers may experience stress to the extent of activating biological stress responses at a greater frequency in comparison to people who work in higher education and undergraduate students. However, no significant differences were observed in the perceived stress levels reported across dementia caregivers, professionals working in higher education and undergraduate students. These findings highlight the requirement to ascertain the extent to which work related tasks or other factors, specific to the profession of caring for people with dementia, could elicit heightened HPA stress reactivity.

Introduction

Approximately 400,000 older adults reside in care homes across the UK (Laing-Busson, 2018), with an estimated 70% of residents having a diagnosis of dementia (Alzheimer's Society, 2019). Caring for older people with dementia, who have complex health and social care needs, can be a highly demanding profession in the care home sector (Kingston, Comes-Herrera & Jagger, 2018). In 2017, it was estimated that 26% of frontline staff left the care home sector to pursue another career, with work related stress being cited as one of the reasons contributing to the high staff turnover rates (Allan & Vadean, 2017). In order to develop strategies to negate stressors and improve staff retention in care homes, there is a need to gain a greater understanding as to how the demand of caring for people with dementia can impact the long-term wellbeing of frontline carers.

Previous studies have used self-reported measures of stress to ascertain how the demands of caring for people with dementia impacts the wellbeing of frontline staff. Rodney (2000) observed that perceived threat of aggression, as exhibited by residents in the care home environment, is associated with higher levels of self-reported stress in dementia carers. Self-reported measures have also been used to illustrate how factors such as lack of training and supervision could contribute to high stress levels experienced by dementia carers (Edvardsson, Sandman, Nay & Karlsson, 2009). Zimmerman, et al., (2005) also used subjective measures of stress when observing that professional dementia carers who are less experienced in their role report higher levels of stress than dementia caregivers who have more than two years of experience in their role. However, studies that have used self-reported measures of stress do not provide an indication of the biological stress experienced by frontline carers of people who have dementia. The use of biological markers of stress may, therefore, further our understanding of the stress levels experienced by professional dementia caregivers.

Hair cortisol concentration (HCC) has been recognised as a biological marker of Hypothalamic-Pituitary-Adrenal (HPA) axis activity and chronic stress (Russell, Koren, Rieder & Van Uum, 2012). Chronic activation of the HPA axis can have deleterious effects on immune system functioning, which can contribute to the manifestation of physical ill health (Glaser & Kiecolt-Glaser, 2005), and degradation to hippocampal functions that can lead to deficits in cognitive functioning (Raber, 1998). High stress burden and biological dysregulation, including perturbations of the HPA axis, are also a common feature of informal caregiving (Lovell & Wetherell, 2011). Accordingly, significantly higher levels of HCC have previously been observed in the informal carers of people with dementia when compared to older adults who did not have caregiver responsibilities (Stalder, Tietze, Steudte, Alexander, Dettenborn & Kirschbaum, 2014). Elevated levels of HCC have also been observed in professions which include caregiving among their responsibilities. In a sample of workers in residential youth welfare organisations, Kind, Eckert, Steinilin, Schmeck, Fegert & Schmid (2018) reported the highest levels of HCC in those workers who experienced more incidences of physical and verbal aggression from those in their care.

HCC has also been used as a marker of stress in medical professionals who have significant caring responsibilities and experience high levels of work-related stress. In addition, newly qualified doctors experience high work demands while lacking experience and control over their environment and this makes them susceptible to psychological and physical morbidity through dysregulation of the HPA axis (Brant, Wetherell, Lightman, Crown & Vedhara, 2009). In support, Mayer, Lopez-Duran, Sen & Abelson (2018) observed elevated levels of HCC in the first two months and towards the end of a medical internship reflecting the initial onset and subsequent chronic stress associated with the first experiences of professional clinical training. HCC has also been used as a marker of HPA function in other medical professionals. For example, a sample of paediatric oncologists, a profession characterised by

child suffering, loss, bereavement, and high rates of burnout, demonstrated HCC levels approximately double that of a student sample (Lamothe, Rondeau, Duval, McDuff, Pastore & Sultan, 2020). Most recently, elevated HCC levels have been assessed in healthcare professionals during the COVID-19 pandemic capturing the burden of work stress during an international health emergency characterised by uncertainty, increased workload and significant risk. Perhaps unsurprisingly, levels of HCC were higher in nurses during the first wave of the pandemic compared with levels prior to COVID-19, and the greatest HCC levels were observed in those nurses with more contact with COVID-19 patients (Rajcani, Vytkačová, Solariková & Brezina 2021). Ibar et al. (2021) also identified the importance of direct contact with COVID-19 patients in relation to elevated HCC. Physicians, nurses, and other frontline staff had higher HCC levels than non-patient facing professionals, with the highest levels observed in those workers who met the criteria for burnout.

Taken together, this evidence suggests that HCC is a marker of HPA dysfunction in individuals who experience stress as a function of providing care and could therefore be useful in assessing stress and HPA function in professional carers of people with dementia. This is therefore, the first study to assess HCC and perceived stress in professional carers of people with dementia in comparison to other groups who may also be prone to stress, specifically employees who work within higher education (Kinman & Court, 2010) and undergraduate students (Robotham, 2008).

Method

Design

A between-subjects design was employed in the current study. The independent variable was the occupation of participants and had 3 levels; 1) professional dementia carers, 2) employees working in higher education (Academics/Support Staff) and 3) undergraduate students. This study had 2 dependent variables of interest, which were levels of HCC in pg/mg and self-reported stress as measure using the Perceived Stress Scale (Cohen, Karmarck & Mermelstein, 1983).

Participants

Caregivers were recruited through professional networks. Care home managers were contacted to distribute information about the study to their staff; those interested in participating were given information sheets, and if prepared to participate in all aspects of the study were asked to provide informed consent. Professionals working in higher education and students were recruited through advertisements on university wide information screens and emails sent within the university. All participants were required to be aged 18 years or over at the time of data collection and be either a) employed in the direct care of people with dementia within a care home setting, b) working as a professional in higher education, or c) an undergraduate student. No other exclusion criteria were applied in order to ensure the recruitment of representative samples.

Hair samples were taken from 168 participants for HCC analysis. The study comprised of 34 professional carers of people with dementia, 32 females (mean age = 46.19, SD = 10.91) and 2 males (Mean age = 24.50, SD = 4.95). Hair samples were also provided by 46 professionals working in higher education, 43 of which were females (mean age = 38.45, SD = 10.61) and 3 were males (mean age = 31.89, SD = 7.97). Finally, 88 of the participants were

undergraduate students, 67 of which were females (mean age = 24.04, SD = 7.27) and 21 were males (mean age = 23.91, SD = 6.10). The professional dementia caregivers had been in their role for a mean time of 83.85 months (SD = 84.85), ranging from having 1 to 384 months of experience.

Materials

Hair samples

Hair cortisol was analysed at the ARU Biomarker Laboratory, Cambridge. Hair segments 1cm proximal to the scalp were assessed in this study to provide an indication of cortisol production over the previous 1-month period (Wennig, 2000). This time window corresponds with self-reported stress through completion of the Perceived Stress Scale (Cohen, Kamarck & Mermelstein, 1983; PSS). Further, levels of HCC in hair segments of less than 3cm proximal to the scalp are not affected by frequency of hair washing (Dettenborn, Tietze, Kirschbaum, & Stalder (2012). Thus, when required for analysis, a 1cm segment from the scalp end of each hair sample was cut (using surgical scissors) and 25mg of the hair samples was placed in a 4.5ml polypropylene copolymer (PPCO) vial. It was not always possible to get 25mg of hair from each participant's sample and in these cases we used the amount of hair available and the weight of each individual sample of hair was accounted for in the subsequent calculation of HCC. The hair samples were then washed in 1ml of isopropanol to remove external contaminants, the isopropanol was removed from the vial and the hair allowed to dry in a clean air environment for 48 hours. Once fully dry five ceramic balls were added to each tube and the hair samples ground to a powder using an Fast Prep-24 (MP Biomedicals, LLC). To extract cortisol, we added 2ml of methanol to each sample and incubated the samples for 24 hours rotating the samples constantly.

The hair, methanol and ceramic balls were decanted into a polypropylene tube (Sarstedt AG & Co, Germany) that separated the ceramic balls from the rest of the mixture. The tube was centrifuged at 3000 RCF to separate the ground hair and methanol and 1.4ml of the clear methanol supernatant was decanted into a 2ml polypropylene cryovial. The methanol was then removed using a vacuum centrifuge (Scan Speed 40, Labgene) and the tubes frozen at -80°C until required for the cortisol ELISA. Cortisol levels were determined using a commercially available competitive ELISA (Salimetrics, US). Samples were thawed and reconstituted with 0.125ml of Salimetrics cortisol assay diluent and the samples were then assayed in accordance with the manufacturer's protocol. Samples were analysed in duplicate and mean values are reported. The intra assay coefficient of variance for the dementia professional dementia carers sample was 5.82%. The intra assay coefficient of variance for the employees working in higher education and undergraduate student samples was 1.4%. The inter assay coefficient of variance for all 3 occupational groups was 4.68%. The HCC were expressed as the picograms of cortisol per milligram of hair

Perceived Stress

The Perceived Stress Scale (Cohen, Kamarck & Mermelstein, 1983; PSS) was developed as a self-reported measure to tap into levels of subjective stress as experienced over a preceding month. The PSS comprises 10 items and requires participants to state the extent to which they had experienced subjective stress over the previous month. Participants are required to respond on a 5-point Likert scale ranging from 0 = never to 4 = very often. The scores derived from the PSS range from 0 – 40, with higher scores indicating greater levels of perceived stress experienced over the month prior to the date of data collection. The PSS taps into a single construct of perceived stress and has a Cronbach's alpha in the current sample of 0.85.

Procedure

Ethical approval for this study to be conducted was granted by the research ethics committees with the School of Health and Life Sciences at the University of Northumbria at Newcastle and the Faculty of Science & Technology at Anglia Ruskin University. The 34 dementia carers all met with the principal researcher (author D.R) as a single group within a care home setting and were briefed on the aims of the study. The dementia carers were then required to provide written informed consent to document that they agreed to provide hair samples for the purpose of the study. Participants then completed the Perceived Stress Scale (Cohen, Kamarck & Mermelstein, 1983). Once all of the hair samples had been collected by the researcher (author D.R), the dementia carers received a debrief from the researcher and were thanked for their participation in the study. Hair samples and completed PSS, as provided by staff working in higher education and undergraduate students, were collected by researchers at the Biomarker Analysis Laboratory at Anglia Ruskin University. Informed consent was obtained from all participants prior to data collection.

Statistical analyses

Higher levels of HCC have been observed in older adults and in males (Dettenborn, Tietze, Kirschbaum & Stalder, 2011), and perceived stress can vary as a function of age and gender (Cohen & Janicki-Deverts, 2012). Thus, one-way ANCOVAs were conducted to determine whether there were any differences in HCC and perceived stress levels between professional dementia carers, staff working in higher education and undergraduate students while controlling for any effects of age and gender. Post-hoc analyses were conducted as appropriate. Adopting the principles of Cook's Distance (Cook, 1979), data points that were indicative of HCC levels being 3 times greater than the group mean were removed from the data set prior to analysis. This led to data from 2 participants from the dementia carer group

(with HCC levels at 2199.28 pg/mg and 293.73 pg/mg) being removed from the data set prior to analysis. Data from 1 participant from the higher education staff participant group was also removed from the data set where the HCC level was reported as being 73.76 pg/mg.

The HCC data was observed to be positively skewed, therefore log₁₀ transformations were applied in order to establish a normal distribution. The original units of HCC (pg/mg) are reported in the results section when referring to descriptive statistics. The Shapiro Wilk test indicated that the PSS data was normally distributed, $p = 0.18$.

Results

Means, standard deviations, and ranges for HCC and perceived stress in professional dementia carers, higher education staff, and students are presented in Table 1.

A one-way ANCOVA indicated a significant difference in HCC levels between the 3 groups, while controlling for age and gender, $F(2, 161) = 7.11, p = .001, \eta_p^2 = .08$, observed power = 0.93. Post-hoc analysis, using the Bonferroni correction, indicated that higher levels of HCC were observed in the professional dementia caregivers ($M = 13.48$ pg/mg, $SD = 9.57$) in comparison to staff working in higher education ($M = 8.21$ pg/mg, $SD = 5.31, p < .01$) and undergraduate students ($M = 6.92$ pg/mg, $SD = 3.27, p < .01$). However, the comparisons in HCC levels between staff working in higher education and undergraduate students were non-significant ($p > .05$), when controlling for age and gender. This suggested that professional dementia carers had greater HPA activation and cortisol secretion over a 1-month period, than employees working in higher education and undergraduate students. Mean (SD) HCC are presented in Figure 1.

A one-way ANCOVA revealed no significant difference between dementia carers ($M = 19.94$, $SD = 7.94$), staff working in higher education ($M = 19.29$, $SD = 6.71$) and undergraduate students ($M = 19.77$, $SD = 6.95$) in perceived levels of stress after controlling for age and gender $F(2,164) = .34$, $p = .72$, $\eta_p^2 = .004$ observed power = 0.10. This suggested that there were no differences in the levels of perceived stress experienced by dementia carers, staff members in higher education and undergraduate students.

Table 1. Means, standard deviations and ranges for scores on the Perceived Stress Scale and hair cortisol concentrations for professional dementia carers, staff in higher education and undergraduate students.

	Dementia carers (N=32)	Academic / support staff (N=45)	Students (N=88)
Hair Cortisol Concentration			
Mean	13.48	8.21	6.92
SD	9.57	5.31	3.27
Range	2.13-37.43	2.35-26.91	2.04-17.54
Perceived Stress			
Mean	19.94	19.29	19.77
SD	7.94	6.71	6.95
Range	1-36	5-34	5-31

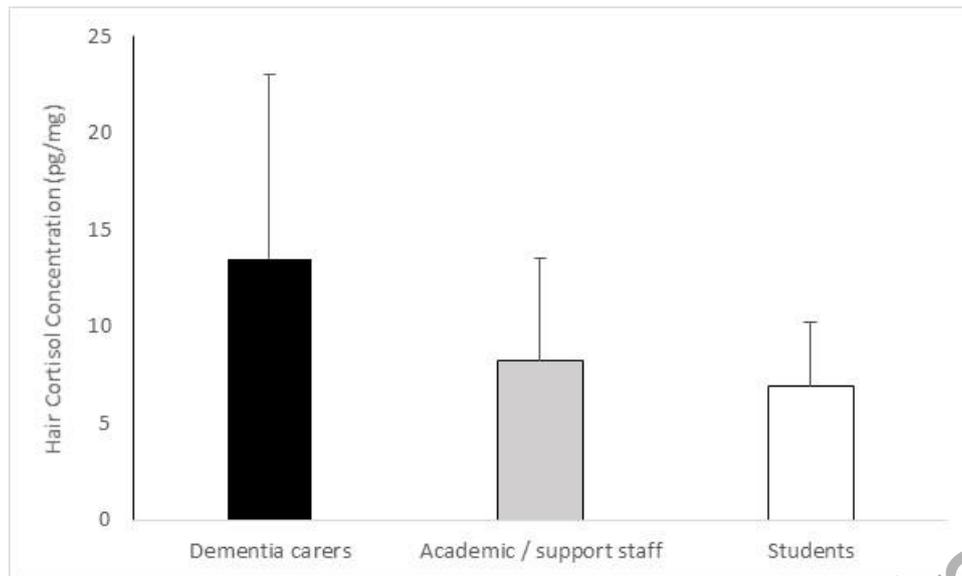


Figure 1. Mean (SD) hair cortisol concentrations in professional dementia carers, staff in higher education and undergraduate students.

Discussion

The current study assessed whether higher levels of HCC would be observed in professional dementia carers in comparison to employees working in higher education and undergraduate students. Higher levels of HCC were observed in professional dementia carers than in employees working in higher education and undergraduate students when controlling for age and gender. This converges with observations showing elevated levels of HCC in informal caregivers of people with dementia in comparison to non-caregivers (Stalder, Tietze, Steudte, Alexander, Dettenborn & Kirschbaum, 2014), and adds to the literature linking the burden of caregiving to increased physical and psychological morbidity through dysregulation of biological pathways (Lovell & Wetherell, 2011). This study demonstrates that providing care for people with dementia could involve demands that trigger the HPA axis at a greater frequency/intensity in comparison to the stressors that occur within staff members in higher

education and undergraduate students. However, no differences in perceived stress levels were observed between the three occupational groups.

The results of this study indicated that professionals who care for people with dementia may be more vulnerable to the deleterious consequences of chronic activation of the HPA axis than professionals working in higher education and undergraduate students. Chronic biological stress can potentially contribute to mental fatigue (Raber, 1998) and physical exhaustion (Glaser & Kiecolt-Glaser, 2005), which are characteristics of burnout (Danhof-Pont, van Veen & Zitman, 2011). Thus, an implication of this finding is that professional dementia carers may be more vulnerable to experiencing physical ailments and impaired cognition, as caused by the repeat activation of the HPA axis, in comparison to employees who work in higher education and undergraduate students. This may help to explain the high staff turnover rates observed in the care home sector, in which work related stress has been posited as a contributory factor (Allan & Vadean, 2017). Thus, there is a need for subsequent studies to further explore if any relationships in HCC levels and symptoms of burnout, such as the regular onset of physical ailments and impaired cognition, can be observed in professionals who care for people with dementia. A number of factors have also been identified as sources of stress in the care sector, such as inadequate working environments and ruminating on challenging situations that occur in the workplace setting (Rippon, McDonnell, Smith, McCreadie & Wetherell, 2020). It is therefore recommended to investigate whether occupational stressors associated with caring for people with dementia, such as encountering residents who exhibit behaviours that challenge (Rodney, 2000), lack of supervision (Edvardsson, Sandman, Nay & Karlsson, 2009) and inexperience (Zimmerman, et al., 2005) are significant predictors of HCC levels. This would help to inform the extent to which specific occupational stressors can explain any manifestation of chronic biological stress as experienced by professional dementia caregivers. The identification of relationships

between specific occupational stressors and HCC levels could also inform the development of stress reduction interventions. For example, Schmid, Lüdtke, Dolitzsch, Fischer, Eckert & Fegert (2020), observed reductions in HCC levels in residential youth careworkers who engaged in Trauma-informed care (TIC) training, a therapeutic approach that promotes self-care and facilitates a better understanding of stress symptoms in both carers and their clients. TIC also led to fewer incidences of aggression from residents. As the experience of aggression is a primary source of stress in frontline careworkers (Rippon et al., 2020) and is associated with elevated levels of HCC in youth careworkers (Kind et al 2018), this finding offers a promising opportunity for intervention that could be applied in other carer groups.

Despite differences in HCC, there were no differences between the groups in levels of self-reported perceived stress. Existing literature has suggested that staff working in higher education and students could also be prone to experiencing stress. Factors such as inadequate support from senior managers, high workloads and excessive working hours, and insufficient recognition for professional input have negative consequences on the personal wellbeing of academics and support staff working within university settings (Gillespie, Walsh, Winefield, Dua, & Stough, 2001, Kinman & Court, 2010). Undergraduate students have also been acknowledged as an at-risk group of experiencing stress due regular examinations, financial hardships, and the novel challenges associated with living away from the family home (Robotham, 2008). These causes of stress are evidenced in the current study where staff in higher education and undergraduates reported perceived stress levels to the same extent as professional carers of people who have dementia. While these results do suggest that staff in higher education and students do experience high levels of stress, there is not always an association between levels of HCC and self-reported stress (Stalder et al., 2017). In the present study, it was the dementia caregivers who demonstrated greater HPA activity over a 1-month period.

In the absence of any measures of occupational stress, the extent to which the high levels of HCC observed within the dementia carers were attributable to work related stress is unclear. Elevated HCC levels can be elicited by other factors such as chronic pain (Van Uum, Sauve, Fraser, Morley-Forster, Paul & Koren, 2008), extreme physical exertion (Skoluda, Dettenborn, Stalder & Kirschbaum, 2012) and non-work-related life events (Karlen, Ludvigsson, Frostell, Theodorsson & Faresjo, 2011). Thus, the dementia carers in the current study may have experienced life events that were not related to their profession within the 1-month preceding the collection of hair samples but contributed to the observed elevation in HCC. This is a significant concern given the demographic structure of the workforce in the care sector. A recent UK survey (Skills for Care, 2018) reports that careworkers are predominantly female, comprise a greater proportion of Black, Asian and Minority Ethnic (BAME) employees than in the overall population, and over one quarter are employed on casual contracts. This figure rises to 58% in some care sectors, representing a significant proportion of the care workforce on precarious employment and low pay. These factors could potentially elicit physical and mental health problems and are significant contributors to health inequalities (Marmot, Allen, Boyce, Goldblatt & Morrison, 2020). For some carers therefore, the deleterious impact of caring may be compounded by these additional stressors further highlighting their vulnerability and need for intervention. It is therefore suggested that data concerning everyday stressors, such as pain/illness experienced, exercise activity, general life events, and pertinent demographic factors are also collected when using HCC as a biological marker to investigate occupational stress in dementia care professions. This would help to provide an indication of the extent to which work related stress and everyday stressors contribute to levels of HCC observed over a given period of time. Nonetheless, regardless as to whether stressors occur within or outside of the workplace, the HCC levels

observed in dementia carers as part of this study, suggests that they are an occupational group that warrant attention in terms of implementing strategies to reduce stress.

Future studies may also employ comparator groups that experience similar occupational demands to that of dementia caregivers. For instance, exposure to behaviours that challenge can be a work related stressor for dementia caregivers (Rodney, 2000), healthcare professionals working in Accident & Emergency departments (Sowney & Barr, 2006), teachers (Hastings & Bham, 2003), and residential youth workers (Kind et al., 2018). Moreover, other caring professions, for example, medical interns (Mayer et al., 2018), paediatric consultants (Lamothe et al., 2020), nurses and physicians (Rajcani et al., 2021; Ibar et al., 2021) are also characterised by chronic activation of the HPA axis as evidenced by elevated levels of HCC. A focus on other comparator professions with similar sources of stress will help to ascertain those factors that may be responsible for elevated HCC in frontline caring professions.

It must also be acknowledged that participants across the three groups were not matched or excluded on variables which could influence HCC levels or HPA axis activity. For instance, a meta-analysis also revealed that Body Mass Index (BMI) may also be a predictor of HCC levels (Stalder et al., 2017). This was not assessed in the current study and it is therefore recommended that subsequent studies that compare HCC levels in dementia caregivers to other professions, employ matched controls on variables, such as gender and BMI. Positive correlations have also been observed between the dosage of the glucocorticoid treatments, such as hydrocortisone, and HCC levels (Gow, Koren, Rieder, & Van Uum, 2011). Thus, it may also be beneficial for subsequent studies to screen participants for medication use as a means to avoid the recruitment of employees who are prescribed medications that contain

glucocorticoids and potentially influence HCC levels. This would help to reduce the influence of extraneous variables, such as the use of glucocorticoid treatment, when ascertaining the extent to which specific occupational stressors can explain the HCC levels observed in professional carers of people with dementia. It should also be noted that this study is cross-sectional and future studies could usefully employ longitudinal designs. One advantage of HCC in a longitudinal design is that it allows for retrospective assessment of HPA function, and if hair length allows, one sample could be used to assess a period of time that may be characterised by quantifiable differences in the caregiving experience, for example, the commencement of a caregiving role.

Conclusion

There has been a growing interest in the use of HCC to assess biological stress levels in various health and frontline care professions. This is the first study to assess HCC and perceived stress in professional carers of people with dementia. The current study observed higher levels of HCC in professional dementia carers in comparison to professionals working within higher education and undergraduate students after controlling for age and gender. There were, however, no differences in levels of perceived stress between the groups. Assuming the elevated levels in HCC in dementia caregivers are a consequence of the heightened levels of stress experienced by this group, there is a need to identify these stressors and to identify protective factors to support people working in this occupation. It is suggested that further research seeks to identify other factors that may increase stress burden in caregivers and investigate whether there are any work-related tasks, specific to the profession of caring for people with dementia, that may elicit prolonged HPA stress reactivity as these may provide targets for intervention.

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