BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-048658
Article Type:	Original research
Date Submitted by the Author:	04-Jan-2021
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Keywords:	EPIDEMIOLOGY, MENTAL HEALTH, Medical retina < OPHTHALMOLOGY, PUBLIC HEALTH

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Cross-sectional study evaluating burden and depressive symptoms in family carers of persons with age-related macular degeneration in Australia

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Abstract

Objectives: We aimed to quantify the degree of carer burden and depressive symptoms in family carers of persons with age-related macular degeneration (AMD) and establish the factors independently associated with carer burden and depressive symptoms.

Methods: Cross-sectional study using self- and interviewer-administered surveys, involving 96 family carer-care recipient pairs. Participants were identified from tertiary ophthalmology clinics in Sydney, Australia, as well as the Macular Disease Foundation of Australia database. Logistic regression, Pearson and Spearman correlation analyses were used to investigate associations of explanatory factors, (family caregiving experience, carer fatigue, carer quality of life and care recipient level of dependency) with study outcomes - carer burden and depressive symptoms.

Results: Over one in two family carers reported experiencing mild or moderate-severe burden. More than one in five and more than one in three family carers experienced depressive symptoms and substantial fatigue, respectively. High level of care recipient dependency was associated with greater odds of moderate-severe and mild carer burden, multivariable-adjusted OR 8.42 (95% CI 1.88-37.60) and OR 4.26 (95% CI 1.35-13.43) respectively. High levels of fatigue were associated with 3-fold greater odds of the carer experiencing depressive symptoms, multivariable-adjusted OR 3.47 (95% CI 1.00-12.05).

Conclusions: A substantial degree of morbidity is observed in family carers during the caregiving experience for patients with AMD. Level of dependency on the family carer and fatigue were independently associated with family carer burden and depressive symptoms.

Strengths and limitations of this study

- The study design and method of surveying allowed for the collection of rich and extensive data from patients with AMD and their family carers.
- Several validated scales for the assessment of both carer and patient variables were used, including those for burden, depression, fatigue and visual functioning.
- Study participants were recruited from only one state in Australia
- Due to the relatively small sample size, the study is likely to be underpowered for detecting modest associations

Contributors

All authors—IJ, DT, GB, JG, KNP, AC, GL, PM and BG—provided inputs in study design. IJ, DT, JG, GB, PM and BG were involved in data collection and data analysis. IJ, JG and BG were responsible for publication writing. All authors reviewed and approved the final version of this manuscript.

Funding

This work was supported by the Australian National Health and Medical Research Council under a Partnership Project Grant (APP1115729); and the Macular Disease Foundation Australia.

Competing interests

None of the authors declared a conflict of interest.

Patient consent

Obtained.

Ethics approval

University of Sydney human research ethics committee.

Acknowledgements

The authors thank all individuals for their time and participation in the study.

Introduction

Age-related macular degeneration (AMD) is a chronic and progressive disorder of the macula[1] and is the leading cause of blindness and low vision in Australia, directly affecting more than 1 million persons[2,3]. The effects of vision impairment in AMD are not limited to declining visual function, with several studies showing that AMD affects multiple health domains and leads to significant emotional distress, poorer quality of life and reduced functional independence[4,5]. For many patients, the ongoing nature of a chronic illness like AMD is such that it requires the provision of continuous physical and emotional care beyond the scope of what can be currently provided by hospitals or other institutions[6,7]. Family carers of relatives with AMD are often expected to provide a high standard of care despite not receiving formal training and adequate support for this role[8,9]. Surveys on the perceptions of family carers of relatives with AMD in their role as informal carers, demonstrate experiences of significant psychological distress, with the negative impacts of caring extending to increased financial stress, disruptions to lifestyle and retirement plans, and added strain on the relationship between carer and care recipient[5,10].

Clearly, the impacts of AMD are far-reaching, with significant influence on family, friends and carers, as well as substantial cost to society[3,11]. However, currently there exists little literature reporting on the level and factors of burden and depressive symptoms experienced by family carers of relatives with AMD. As such, the key aims of this cross-sectional study were to: 1) Quantify the degree of carer burden and depressive symptoms in family carers of persons with AMD; and 2) Establish the factors that were independently associated with carer burden and depressive symptoms.

Methods

Participants

Participants for this study were recruited as a part of a randomised controlled trial implementing a novel multi-component intervention targeting the drivers of stress and burden in family carers of patients with AMD. This report analysed a total of 96 patients with AMD and 96 of their family carers who were examined at baseline (pre-intervention). Recruitment of participants occurred between January 2017 to May 2020 across multiple ophthalmology practices in Sydney, Australia, as well as via the Macular Disease Foundation Australia (MDFA) database of members. The inclusion criteria for eligible family carers participating in this study were: adults aged more than 18 years old; family carer of a relative with AMD; willing to engage in a 10-week cognitive behavioural therapy intervention over a 3-month period; and sufficient English fluency to effectively engage in the intervention. All participants in this study gave written informed consent. Ethics approval was obtained from The University of Sydney Human Research Ethics Committee (ID# - 2016/793). Information on baseline study participant characteristics were obtained via surveys of family carers and their relatives with AMD, completed on-site during clinic visits or at home either independently or with help from the study coordinator e.g. due to limitations imposed by poor vision.

Patient and Public Involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

Sociodemographic information and medical history

All participants (carers and care recipients with AMD) provided sociodemographic information including: age, sex, education level and marital status. They also self-reported any medical conditions such as: heart attacks; angina (without myocardial infarction); any other cardiac conditions; strokes or transient ischaemic attacks; high blood pressure; high cholesterol;

diabetes or prediabetes; kidney disease; arthritis; hearing loss; and visual impairment. This information was used to assess the general health status (GHS) of each participant. Participants who reported 3 or more health conditions were considered as having substantial comorbidity and received a score of 1, whereas those with fewer than 3 health conditions received a score of 0.

Carer variables

Family carers were asked to provide details about the patient with AMD that they cared for such as whether they were the sole caregiver of the patient; the type of caregiving duties performed and the hours of care they provided to the care recipient with AMD. This comprised of 21 questions detailing caregiving duties as they applied to typical activities of daily living and instrumental activities of daily living for the patient with AMD, including exercise and/or sport, cooking and preparing food, cleaning, reading, personal grooming, using public transport, driving and more. Each question was scored reflecting the degree of help given for each activity *(0=no help or little help given, 1=moderate amount of help given, 2=high amount of help given, 3=not applicable).* Additional information on family carers was determined by administering several validated instruments and scales as detailed below:

(i) Carer burden. The Caregiver Burden Scale (CBS) is a 22-item questionnaire originally developed for assessment of perceived family carer burden in caring for patients with dementia[12,13]. Each question was scored on a 5-point Likert-type scale *(0=never, 1=rarely, 2=sometimes, 3=quite frequently, 4=always)*, reflecting the frequency of family carers' feelings when taking care of their family member. The total burden score calculated for each family carer was used to stratify levels of burden into 3 categories, with higher scores indicating

higher levels of burden (*0-20=no/little burden, 21-40=mild burden, ≥41=moderate-severe burden*).

(ii) Depressive symptoms. The short form of the Centre for Epidemiologic Studies Depression (CESD-10) scale is a 10-item questionnaire and was used to screen for symptoms of depression[14]. Each question gauges the frequency of a family carer experiencing certain symptoms of depression per week and is scored on a 4-point Likert-type scale *(0 = rarely or none of the time (<1 day), 1=some or a little of the time (1-2 days), 2=occasionally or a moderate amount of the time (3-4 days), 3=most or all of the time (5-7 days))*. A total CESD-10 score of 10 or more indicates significant presence of depressive symptoms, as reported by previous research evaluating the validity of the CESD-10 scale[14]. The CESD-10 is a validated and reliable measure[14].

(iii) Fatigue. The Fatigue Severity Scale (FSS) is a 9-item questionnaire used frequently to assess the degree of impact that fatigue has on an individual's activities and physical functioning[15]. Participants were asked to respond to statements about how much fatigue impacted their ability to function on a scale of 1 *(disagree)* to 7 *(agree)*. Previous studies have shown mean (SD) FSS scores for healthy individuals to be 2.3 (0.7) (ref. 15). Mean FSS scores of 4 or more were categorised as having problematic fatigue. The FSS is a validated and reliable measure[15].

(iv) Self-efficacy. The General self-efficacy (GSE) scale is a 10-item questionnaire shown to be effective at measuring one's beliefs of overall ability to succeed in specific situations[16]. The degree of how much a family carer agreed with each statement was measured using a 4-point

Likert-type scale *(0=not true, 1=hardly true, 2=moderately true, 3=exactly true)*. Higher total GSE scores indicate higher self-efficacy.

(v) Dependency. Carers were asked to quantify the level of dependence their family member with AMD had on them since their diagnosis using a 4-point Likert-type scale *(1=not at all dependent, 2=somewhat dependent, 3=moderately dependent, 4 = very dependent, 5 = extremely dependent)*. Scores 3 or more were interpreted as an indication of high dependency on the family carer *(1-2 = low dependency, 3-5 = high dependency)*.

(vi) Quality of life. Carer's rated their general quality of life (GQL) on a linear scale from 0 *(poor quality of life)* to 10 *(excellent quality of life)*.

Care recipients with AMD

The National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25) was completed by care recipients, and is a reliable and validated tool used to measure status of vision-related health impairment most relevant to patients with chronic eye conditions[17]. Questions in the NEI VFQ-25 were used to determine the extent of how visual disability and symptoms negatively impacts the patient's ability to function, well-being and efficacy in achieving vision-related tasks. The NEI VFQ-25 is comprised of 12 subscales, assessing general vision, near and distance vision, vision-related difficulty with activities, vision-related driving problems, eye pain, colour vision, dependency, impact on social functioning, mental health and general health[17]. Scores recorded in the original response category for each question were recoded to a scale between 0-100 in accordance with the NEI VFQ-25 scoring algorithm, with higher scores indicating greater vision-related well-being.

Statistical analysis

SAS statistical software (SAS Institute, NC, v9.4) was used for the statistical analysis, including t-tests, chi-squared tests and logistical regression. A stepwise logistical regression analysis utilising a forward selection procedure was performed to assess potential predictors of study outcomes - carer burden and depressive symptoms. Predictor variables assessed for both these study outcomes were: carer age, carer sex, carer general quality of life, carer general health status, fatigue severity, general self-efficacy, level of dependency on the carer, patient age, patient sex, patient general health status and patient NEI VFQ-25 scores. The CORR procedure was used to compute the Pearson correlations and Spearman rank-order correlations between presence of depressive symptoms (CESD-10 score) and the following variables: patient age and sex, and carer variables (age, sex, general quality of life scores, fatigue severity scale scores, carer and patient general health status, general self-efficacy, level of dependency on the carer and NEI VFQ-25 scores). The significance level was <0.05.

Results

AMD caregiving experience and health-related variables

The majority of family carers (91%) were aged 50 years and over, with family carers aged 65 years or older making up 54% of the sample. The proportion of females was 78% and 66% among family carers and care recipients with AMD, respectively. Of the 96 family carers in this study, 75% were the sole carer of the patients with AMD, with 43% reporting that the family member they cared for was highly dependent on them. Responses to questions about the impact of providing care to a family member with AMD on the carer's state of mind showed that many carers experienced feeling frustrated (43%), depressive (31%) and sad (27%). Some carers reported feeling no different (26%), with a relatively smaller proportion of carers reporting positive impacts in relation to their caregiving experience, such as feeling more

content in their lives (13%), feeling happier than ever before (13%), feeling more optimistic (8%) and feeling more determined (7%). Family carers played a considerable role in helping their relatives access medical care, with 91% accompanying their relatives to their ophthalmology appointments where the majority of relatives with AMD (79%) were receiving anti-VEGF injections. In terms of how often help was provided to relatives with AMD, 61% of family carers reported providing help for 7 days a week on average, with 45% reporting either spending >8 hours per day with them or living together with the care recipient. The main caregiving duties where carers provided moderate to high amounts of help included cooking (57%), cleaning (60%) and help with leaving the house (70%).

Substantial amounts of fatigue were experienced by 36% of family carers as indicated by scores of 4 or higher on the fatigue severity scale, and a considerable degree of general health comorbidities was reported by 29% of family carers. The mean quality of life and general self-efficacy scores among the family carers in this study were: 7.3 (SD 2.0) and 32.5 (SD 4.9), respectively.

Burden analysis

More than half of family carers reported experiencing mild (35%) and moderate-severe (22%) burden due to their caregiving experience (Table 1). Family carers of highly dependent relatives with AMD were more likely to experience moderate-severe and mild burden after multivariable adjustment: OR 8.42 (95% CI 1.88-37.60) and 4.26 (95% CI 1.35-13.43), respectively (Table 2). Marginally significant associations were observed between the age and visual functioning of the care recipient with AMD and the level of burden experienced by family carers (Table 2). Table 3 shows that younger carer age, older care recipient age, higher fatigue severity, high level of dependency on the carer and lower NEI VFQ-25 scores were significantly correlated with more carer burden. No statistically significant correlations were

observed between carer burden scores and carer sex, patient sex, carer GQL scores, carer and patient GHS scores, and carer GSE scores (data not shown).

Depressive symptoms

Over one in five family carers (24%) experienced elevated depressive symptoms as determined by the CESD-10 scale. Table 4 shows that family carers with higher levels of fatigue were more likely to experience depressive symptoms: OR 3.47 (95% CI 1.00-12.05). Conversely, each unit increase in family carer GQL scores was associated with 40% reduced odds of experiencing depressive symptoms: OR 0.60 (95% CI 0.41-0.88). Statistically significant negative correlations between carer CESD-10 scores and carer GQL and GSE scores and care recipient NEI VFQ-25 scores were observed, and a significant positive correlation was shown between CESD-10 and carer FSS (Table 5). No statistically significant correlations were observed between CESD-10 and carer age and sex, patient age and sex, carer and patient GHS scores, and level of dependency on the carer (data not shown).

Discussion

This novel study shows that family carers experience substantial levels of burden, depressive symptoms and fatigue when caring for relatives with AMD. The findings from this study are consistent with other studies that demonstrated poorer well-being of family carers of relatives with AMD[18]. Older carers of relatives with chronic disease are themselves biologically vulnerable to disease and are at substantial risk of developing health problems themselves, with studies showing family carers who experienced strain during their experience of providing care to be at greater risk of increased psychiatric morbidity[19,20]. This is also reflected by the finding that nearly a third of family carers in this study were providing care for their relatives with AMD while experiencing significant medical morbidity themselves including, cardiovascular

disease, cerebrovascular disease, kidney disease, arthritis and diabetes. The continuous nature and stresses of providing care, together with burdensome physical and emotional demands on a population already at risk of declining health outcomes is a significant area of concern, not only due to declining health associated with the strain of providing care, but also because any compromise of carer health may in effect lead to inadequate provision of optimal care to the relative with AMD[18,21].

More than half of family carers of relatives with AMD reported experiencing mild or moderate-severe burden. When compared with burden experienced by caregivers of patients with idiopathic Parkinson's disease, a greater proportion of family carers of patients with AMD experience moderate-severe burden (22%) than carers supporting family with early (10%) and late (~12%) stages of idiopathic Parkinson's disease[22]. In contrast, studies on caregivers for patients with stroke report higher levels of moderate-severe burden (~68%) (ref. 23). Interestingly, a recent study on family and unpaid carers of older persons revealed that carers were at greater risk of experiencing burden when caring for patients with dementia with or without substantial disability, but not for those patients with substantial disability in the absence of dementia[24]. While patient functional impairment has been shown to be associated with higher levels of caregiver burden, this suggests that the additional challenges of caring for patients with dementia may be an issue that is not as relevant for the provision of care to patients with AMD[25].

The level of dependency of patients with AMD had on their family carers was independently associated with carer burden. This is in agreement with prior research by our group showing that family carers of patients with AMD that had high levels of dependency on them experience negative impacts such as high levels of emotional distress, as well as disruptions to their lifestyle and retirement plans[5]. Moreover, a systematic review of depression and burden among caregivers of patients with visual impairment found that greater hours of

supervision required and greater limitations in the patients' ability to carry out their activities of daily living, to be among the factors commonly associated with caregiver burden[26], a finding reflected in our study. It is likely that a high level of dependency on family carers may negatively impact the relationship between the carer and care recipient. This could be reflected in the considerable proportion of family carers of relatives with AMD in this study that report feeling frustrated, down and sad during their caregiving experience. Higher levels of dependency by the care recipient could be linked to loss of independence in the family carer due to a lack of time for one's own needs and leisure activities and this in turn could lead to feelings of burden[10]. Moreover, carers have previously reported feelings of guilt from inability to provide the constant and necessary care, with some carers experiencing feelings of being manipulated by the care recipient[5,10]. These feelings of burden due to the AMD caregiving experience can have profound implications on family carer health and well-being.

In contrast, around one in ten family carers of relatives with AMD in this study experienced positive impacts of providing care, including feeling happier and more content with their lives, as well as feeling more optimistic and determined. It is possible that these differences of the caregiving experience among family carers may be related to pre-existing strong familial ties and/or relationships, or otherwise relationships that have strengthened since the need for family caregiving. Indeed, recent research into the role of partner relationship quality and reciprocity (that is, a mutual sense of fair exchange) has shown lower subjective carer burden and higher satisfaction in carers of partners with spinal cord injury, provided the initial relationship quality was high[27,28]. These high-quality relationships may in fact provide the resources and means to alleviate the stress and burden that would otherwise be present during the provision of care[28]. As such, understanding the factors that determine relationship strength and how they can be targeted may be a potential area to address when aiming to improve equity in the family carer-care recipient dynamic.

Over one in five family carers of relatives with AMD experienced elevated depressive symptoms in our study, and this is substantially higher that the global prevalence rates of ~6% (ref. 29). Higher rates of depressive symptoms (~35%) have also been demonstrated in previous studies of family carers of patients with vision loss, along with significant associations between depressive symptoms and younger carer age and poorer patient visual acuity[30]. High rates (40%) of caregivers reporting depressive symptoms were found in a study on family carers of patients with Alzheimer's disease[31]. Higher levels of fatigue were shown to be predictive of family carers experiencing depressive symptoms in our study. This is perhaps unsurprising, given that fatigue and its symptoms are well-known symptoms/predictors of major depressive disorder in the general population[32]. Studies on the emotional well-being of carers of patients with AMD have previously reported increased rates of emotional distress, feelings of frustration, isolation and sadness[5,33,34].

Furthermore, poorer family carer quality of life was significantly associated with depressive symptoms. This association between quality of life and depressive symptoms is consistent with other cross-sectional and longitudinal studies involving older adults[35]. Poor quality of life limits one's ability to carry out their social and occupational activities[36,37]. Previous studies on caregiver quality of life have suggest that financial burden, lack of family/social support, distress and unmet needs are among the factors purportedly increasing the risk of depression and poor mental health outcomes[38-40]. In this way, demonstrable levels of distress and morbidity experienced by family carers of patients with AMD make them "hidden patients" at greater risk of poor health. As such, it is clear that there is a need for evidence-based interventions and education to help increase support for family carers of patients with AMD, thereby minimising their risk of poor health outcomes.

Strengths of this study include the collection of rich and extensive outcome and covariate data from patients with AMD and their family carers, as well as the use of several validated

scales for the assessment of carer and patient variables such as burden, depression, fatigue and visual functioning. However, findings of this study should be interpreted with caution. Due to the relatively small sample size, it is likely that the study was underpowered to detect modest associations. Also, we cannot discount residual confounding from factors that were not measured in our study such as the quality/ strength of the carer-care recipient relationship and other psychosocial measures such as spirituality and carer resilience. Moreover, the cross-sectional study design implemented was useful for investigating the relationships between various factors and health outcomes. However, this design limits our ability to draw conclusions about causality. Future longitudinal studies utilising larger population sets would be useful to affirm the findings of this study.

Conclusion

A substantial proportion of family carers of relatives with AMD experience significant burden and depressive symptoms. Higher levels of dependency and fatigue, as well as lower quality of life were independently associated with higher levels of burden and/or greater odds of depressive symptoms in family carers. These findings underscore the urgent need for evidence-based interventions tailored to family carers of patients with AMD to alleviate their distress and burden, by targeting factors such as fatigue and quality of life, in a timely and effective manner.

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Table 1. Study characteristics of family carers stratified by degree of burden experienced as measured by carer sex, age, general health status, FSS scores, CESD-10 scores, GSE scores, GQL scores, and care recipient sex, age, general health status and NEI VFQ-25 scores (n=96)

	Degree of burden			
Population characteristics	No/little burden (n=41)	Mild burden (n=33)	Moderate-severe burden (n=21)	*P*-value
Carer variables				
Female sex, *n* (%)	28 (68.3)	28 (84.9)	18 (85.7)	0.15
Age, yrs, *mean (SD)*	66.5 (15.6)	63.1 (13.1)	59.1 (10.4)	0.14
General health status				
Substantial comorbidity, *n* (%)	15 (36.6)	11 (33.3)	2 (9.5)	0.07
Fatigue severity scale score				
Problematic fatigue (≥4), *n* (%)	11 (26.8)	11 (33.3)	12 (57.1)	0.06
CESD-10 score				
Presence of depressive symptoms (≥10), *n* (%)	6 (14.6)	7 (21.2)	10 (47.6)	0.01

Total general self-efficacy scores, *mean (SD)*	33.0 (5.4)	32.7 (4.1)	31.0 (4.5)	0.32
Total general quality of life scores, *mean (SD)*	7.6 (1.7)	7.5 (1.8)	6.6 (2.0)	0.09
Patient variables				
Female sex, *n* (%)	25 (61.0)	20 (60.6)	17 (81.0)	0.23
Age, yrs, *mean (SD)*	81.0 (10.1)	84.5 (7.2)	84.4 (11.1)	0.15
General health status				
Substantial comorbidity, *n* (%)	19 (46.3)	15 (45.5)	14 (66.7)	0.25
Total NEI VFQ-25 scores, *mean (SD)*	62.7 (21.0)	53.6 (53.6)	38.6 (20.9)	<0.0001

FSS – Fatigue Severity Scale; CESD-10 – Centre for Epidemiologic Studies Depression-10; GSE – generalised self-efficacy; GQL – General Quality of Life; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

Table 2. Association between selected family carer and care recipient with AMD variables with level of burden among family carers, presented as adjusted odds ratios (OR) and 95% confidence intervals (CI).

	Level of burden, OR (95% CI)*	
Factors	Moderate-severe	Mild
Care recipient age (each 1-unit increase)	0.99 (0.92-1.07)	1.03 (0.97–1.09)
NEI VFQ-25 score (each 1-unit increase)	0.96 (0.93-0.99)	1.00 (0.98–1.02)
High level of dependency on carer	8.42 (1.88-37.60)	4.26 (1.35–13.43)

*Logistic regression model used the burden group 0-20 (no/little burden) as the reference category

Table 3. Spearman correlation coefficients between burden group and carer age, FSS scores, and dependency, and care recipient age and NEI VFQ-25 scores among family carers of relatives with AMD (n=95)

Variable		Carer age	Patient age	Fatigue severity scale	Dependency	NEI VFQ-25
Carer burden scores	*r*	- 0.26	- 0.22	0.22	0.57	- 0.45
	p	0.0115	0.0349	0.0082	<0.0001	<0.0001

FSS – Fatigue Severity Scale; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

Table 4. Associations between selected family carer and care recipient with AMD variables and presence of depressive symptoms among family carers, presented as adjusted odds ratios (OR) and 95% confidence intervals (CI).

Factor	Presence of depressive symptoms, OR (95% CI)
Family Carer	
Age (each 1-unit increase)	0.98 (0.93–1.04)
Female sex	0.58 (0.13–2.60)
General quality of life (each 1-unit increase)	0.60 (0.41–0.88)
Fatigue severity scale score (each 1-unit increase)	3.47 (1.00–12.05)
General self-efficacy (each 1-unit increase)	0.97 (0.86–1.10)
Care recipients with AMD	
Age (each 1-unit increase)	0.98 (0.90–1.05)
Female sex	1.29 (0.29–6.25)
General health status (each 1-unit increase)	1.84 (0.51–6.40)
NEI VFQ-25 (each 1-unit increase)	0.98 (0.95–1.01)

Table 5. Pearson correlation coefficients between presence of depressive symptoms and carer variables (GQL scores, FSS scores, GSE scores) and care recipient NEI VFQ-25 scores among family carers of relatives with AMD (n=96)

Variable		General quality of life	Fatigue severity scale	General self-efficacy	NEI VFQ-25
CESD-10	*r*	- 0.46	0.34	- 0.21	- 0.26
	p	<0.0001	0.0008	0.0391	0.0121

CESD-10 – Centre for Epidemiologic Studies Depression-10; GQL – General Quality of Life; FSS – Fatigue Severity Scale; GSE – generalised self-efficacy; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

BMJ Open

Cross-sectional study evaluating burden and depressive symptoms in family carers of persons with age-related macular degeneration in Australia

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-048658.R1
Article Type:	Original research
Date Submitted by the Author:	15-Jun-2021
Complete List of Authors:	Jin, Ivan; The University of Sydney Tang, Diana; The University of Sydney Gengaroli, Jessica; Australian College of Applied Psychology Nicholson Perry, Kathryn; Australian College of Applied Psychology Burlutsky, George; Melbourne University Craig, Ashley; University of Sydney, Northern Clinical School Liew, Gerald; University of Sydney, Centre for Vision Research Mitchell, Paul; University of Sydney, Centre for Vision Research Gopinath, Bamini; Macquarie University,
Primary Subject Heading:	Ophthalmology
Secondary Subject Heading:	Epidemiology, Mental health, Public health
Keywords:	EPIDEMIOLOGY, MENTAL HEALTH, Medical retina < OPHTHALMOLOGY, PUBLIC HEALTH

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Cross-sectional study evaluating burden and depressive symptoms in family carers of persons with age-related macular degeneration in Australia

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Abstract

Objectives: We aimed to analyse the degree of carer burden and depressive symptoms in family carers of persons with age-related macular degeneration (AMD) and explore the factors independently associated with carer burden and depressive symptoms.

Methods: Cross-sectional study using self- and interviewer-administered surveys, involving 96 family carer-care recipient pairs. Participants were identified from tertiary ophthalmology clinics in Sydney, Australia, as well as the Macular Disease Foundation of Australia database. Logistic regression, Pearson and Spearman correlation analyses were used to investigate associations of explanatory factors, (family caregiving experience, carer fatigue, carer quality of life and care recipient level of dependency) with study outcomes - carer burden and depressive symptoms.

Results: Over one in two family carers reported experiencing mild or moderate-severe burden. More than one in five and more than one in three family carers experienced depressive symptoms and substantial fatigue, respectively. High level of care recipient dependency was associated with greater odds of moderate-severe and mild carer burden, multivariable-adjusted OR 8.42 (95% CI 1.88-37.60) and OR 4.26 (95% CI 1.35-13.43) respectively. High levels of fatigue were associated with 3-fold greater odds of the carer experiencing depressive symptoms, multivariable-adjusted OR 3.47 (95% CI 1.00-12.05).

Conclusions: A substantial degree of morbidity is observed in family carers during the caregiving experience for patients with AMD. Level of dependency on the family carer and fatigue were independently associated with family carer burden and depressive symptoms.

Strengths and limitations of this study

- The study design and method of surveying allowed for the collection of rich and extensive data from patients with AMD and their family carers.
- Several validated scales for the assessment of both carer and patient variables were used, including those for burden, depression, fatigue and visual functioning.
- Study participants were recruited from only one state in Australia
- Due to the relatively small sample size, the study is likely to be underpowered for detecting modest associations

Patient consent

Obtained.

Ethics approval

Ethics approval was obtained from The University of Sydney Human Research Ethics Committee (ID# - 2016/793).

Acknowledgements

The authors thank all individuals for their time and participation in the study.

Introduction

Age-related macular degeneration (AMD) is a chronic and progressive disorder of the macula[1] and is the leading cause of blindness and low vision in Australia, directly affecting more than 1 million persons[2,3]. The effects of vision impairment in AMD are not limited to declining visual function, with several studies showing that AMD affects multiple health domains and leads to significant emotional distress, poorer quality of life and reduced functional independence[4,5]. For many patients, the ongoing nature of a chronic illness like AMD is such that it requires the provision of continuous physical and emotional care beyond the scope of what can be currently provided by hospitals or other institutions[6,7]. Family carers of relatives with AMD are often expected to provide a high standard of care despite not receiving formal training and adequate support for this role[8,9]. Surveys on the perceptions of family carers of relatives with AMD in their role as informal carers, demonstrate experiences of significant psychological distress, with the negative impacts of caring extending to increased financial stress, disruptions to lifestyle and retirement plans, and added strain on the relationship between carer and care recipient[5,10]. Moreover, previous studies based in the UK have shown that caregivers of patients with AMD experience burden levels comparable to those caring for persons with rheumatoid arthritis and multiple sclerosis[11]. Additionally, comorbidity has been shown to be associated with a higher degree of caregiver burden, as demonstrated in other caregiving settings such as for patients with dementia[12]. Furthermore, a significant degree of psychological distress has been reported in caregivers of legally blind patients, with one such study reporting more than a third of caregivers experiencing depression[13]. Previous research conducted by our group on caregiving for AMD have demonstrated that the level of caregiver dependence and the presence of multiple chronic illnesses in the care-recipient were independent predictors of psychological distress[14].

Clearly, the impacts of AMD are far-reaching, with significant influence on family, friends and carers, as well as substantial cost to society[3,15]. However, currently there exists little literature reporting on the level and factors of burden and depressive symptoms experienced by family carers of relatives with AMD. As such, the key aims of this cross-sectional study were to: 1) Analyse the degree of carer burden and depressive symptoms in family carers of persons with AMD; and 2) Explore the factors that were independently associated with carer burden and depressive symptoms.

Methods

Participants

Participants for this study were recruited as a part of a randomised controlled trial implementing a novel multi-component intervention targeting the drivers of stress and burden in family carers of patients with AMD. This study analysed a total of 96 patients with AMD and 96 of their family carers who were examined at baseline (pre-intervention). Recruitment of participants occurred between January 2017 to May 2020 across multiple ophthalmology practices in Sydney, Australia, as well as via the Macular Disease Foundation Australia (MDFA) database of members. The inclusion criteria for eligible family carers participating in this study were: adults aged more than 18 years old; family carer of a relative with AMD; willing to engage in a 10-week cognitive behavioural therapy intervention over a 3-month period; and sufficient English fluency to effectively engage in the intervention. All participants in this study gave written informed consent. Ethics approval was obtained from The University of Sydney Human Research Ethics Committee (ID# - 2016/793). Information on baseline study participant characteristics were obtained via surveys of family carers and their relatives with AMD, completed on-site during clinic visits or at home either independently or with help from the study coordinator e.g. due to limitations imposed by poor vision.

Patient and Public Involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

Sociodemographic information and medical history

All participants (carers and care recipients with AMD) provided sociodemographic information including: age, sex, education level and marital status. They also self-reported any medical conditions such as: heart attacks; angina (without myocardial infarction); any other cardiac conditions; strokes or transient ischaemic attacks; high blood pressure; high cholesterol; diabetes or prediabetes; kidney disease; arthritis; hearing loss; and visual impairment. This information was used to assess the general health status (GHS) of each participant. Participants who reported 3 or more health conditions were considered as having substantial comorbidity and received a score of 1, whereas those with fewer than 3 health conditions received a score of 0.

Carer variables

Family carers were asked to provide details about the patient with AMD that they cared for such as whether they were the sole caregiver of the patient; the type of caregiving duties performed and the hours of care (per day) they provided to the care recipient with AMD. This comprised of 21 questions detailing caregiving duties as they applied to typical activities of daily living and instrumental activities of daily living for the patient with AMD, including exercise and/or sport, cooking and preparing food, cleaning, reading, personal grooming, using public transport, driving and more. Each question was scored reflecting the degree of help given for each activity *(0=no help or little help given, 1=moderate amount of help given,*

2=high amount of help given, 3=not applicable). Furthermore, carers were surveyed to provide details about the impact of providing care to a family member with AMD, including: the impact of carer on the carer's state of mind; ability to manage their own existing health conditions; and impact and change on work, volunteer and recreational activities. Additional information on family carers was determined by administering several validated instruments and scales as detailed below:

(i) Carer burden. The Caregiver Burden Scale (CBS) is a 22-item questionnaire originally developed for assessment of perceived family carer burden in caring for patients with dementia[16,17]. Each question was scored on a 5-point Likert-type scale *(0=never, 1=rarely, 2=sometimes, 3=quite frequently, 4=always)*, reflecting the frequency of family carers' feelings when taking care of their family member. The total burden score calculated for each family carer was used to stratify levels of burden into 3 categories, with higher scores indicating higher levels of burden (*0-20=no/little burden, 21-40=mild burden, ≥41=moderate-severe burden*). The CBS is a reliable measure with a Cronbach's alpha of 0.92[18].

(ii) Depressive symptoms. The short form of the Centre for Epidemiologic Studies Depression (CESD-10) scale is a 10-item questionnaire and was used to screen for symptoms of depression[19]. Each question gauges the frequency of a family carer experiencing certain symptoms of depression per week and is scored on a 4-point Likert-type scale *(0 = rarely or none of the time (<1 day), 1=some or a little of the time (1-2 days), 2=occasionally or a moderate amount of the time (3-4 days), 3=most or all of the time (5-7 days))*. A total CESD-10 score of 10 or more indicates significant presence of depressive symptoms, as reported by previous research evaluating the validity of the CESD-10 scale[19]. The CESD-10 is a validated and reliable measure with a Cronbach's alpha of 0.80[19,20].

(iii) Fatigue. The Fatigue Severity Scale (FSS) is a 9-item questionnaire used frequently to assess the degree of impact that fatigue has on an individual's activities and physical functioning[21]. Participants were asked to respond to statements about how much fatigue impacted their ability to function on a scale of 1 *(disagree)* to 7 *(agree)*. Previous studies have shown mean (SD) FSS scores for healthy individuals to be 2.3 (0.7)[21]. Mean FSS scores of 4 or more were categorised as having problematic fatigue. The FSS is a validated and reliable measure with a Cronbach's alpha of 0.88[21].

(iv) Self-efficacy. The General self-efficacy (GSE) scale is a 10-item questionnaire shown to be effective at measuring one's beliefs of overall ability to succeed in specific situations[22]. The degree of how much a family carer agreed with each statement was measured using a 4-point Likert-type scale *(0=not true, 1=hardly true, 2=moderately true, 3=exactly true)*. Higher total GSE scores indicate higher self-efficacy.

(v) Dependency. Carers were asked to quantify the level of dependence their family member with AMD had on them since their diagnosis using a 4-point Likert-type scale *(1=not at all dependent, 2=somewhat dependent, 3=moderately dependent, 4 = very dependent, 5 = extremely dependent)*. Scores 3 or more were interpreted as an indication of high dependency on the family carer *(1-2 = low dependency, 3-5 = high dependency)*.

(vi) Quality of life. Carer's rated their general quality of life (GQL) on a linear scale from 0 *(poor quality of life)* to 10 *(excellent quality of life)*.

Care recipients with AMD

The National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25) was completed by care recipients, and is a reliable and validated tool used to measure status of vision-related health impairment most relevant to patients with chronic eye conditions[23]. Questions in the NEI VFQ-25 were used to determine the extent of how visual disability and symptoms negatively impacts the patient's ability to function, well-being and efficacy in achieving vision-related tasks. The NEI VFQ-25 is comprised of 12 subscales, assessing general vision, near and distance vision, vision-related difficulty with activities, vision-related driving problems, eye pain, colour vision, dependency, impact on social functioning, mental health and general health[23]. Scores recorded in the original response category for each question were recoded to a scale between 0-100 in accordance with the NEI VFQ-25 scoring algorithm, with higher scores indicating greater vision-related well-being.

Statistical analysis

SAS statistical software (SAS Institute, NC, v9.4) was used for the statistical analysis, including t-tests, chi-squared tests, F-test and logistical regression. The generalised logits model was used for carer burden, given that it is a three-level categorical variable[24]. A binary logistic regression was used for the study outcome of depressive symptoms as it is a two-level variable. For all models, a stepwise selection method was used.

Predictor variables assessed for both these study outcomes were: carer age, carer sex, carer general quality of life, carer general health status, fatigue severity, general self-efficacy, level of dependency on the carer, patient age, patient sex, patient general health status and patient NEI VFQ-25 scores. The CORR procedure was used to compute the Pearson correlations and Spearman rank-order correlations between presence of depressive symptoms (CESD-10 score) and the following variables: patient age and sex, and carer variables (age,

sex, general quality of life scores, fatigue severity scale scores, carer and patient general health status, general self-efficacy, level of dependency on the carer and NEI VFQ-25 scores). The significance level was <0.05. Checks for multicollinearity did not return any confirmation of multicollinearity occurring.

Results

AMD caregiving experience and health-related variables

The majority of family carers (91%) were aged 50 years and over, with family carers aged 65 years or older making up 54% of the sample. The proportion of females was 78% and 66% among family carers and care recipients with AMD, respectively. Of the 96 family carers in this study, 75% were the sole carer of the patients with AMD, with 43% reporting that the family member they cared for was highly dependent on them. Responses to questions about the impact of providing care to a family member with AMD on the carer's state of mind showed that many carers experienced feeling frustrated (43%), depressive (31%) and sad (27%). Some carers reported feeling no different (26%), with a relatively smaller proportion of carers reporting positive impacts in relation to their caregiving experience, such as feeling more content in their lives (13%), feeling happier than ever before (13%), feeling more optimistic (8%) and feeling more determined (7%). Family carers played a considerable role in helping their relatives access medical care, with 91% accompanying their relatives to their ophthalmology appointments where the majority of relatives with AMD (79%) were receiving anti-VEGF injections. In terms of how often help was provided to relatives with AMD, 61% of family carers reported providing help for 7 days a week on average, with 45% reporting either spending >8 hours per day with them or living together with the care recipient. The main caregiving duties where carers provided moderate to high amounts of help included cooking (57%), cleaning (60%) and help with leaving the house (70%).

Substantial amounts of fatigue were experienced by 36% of family carers as indicated by scores of 4 or higher on the fatigue severity scale, and a considerable degree of general health comorbidities was reported by 29% of family carers. The mean quality of life and general self-efficacy scores among the family carers in this study were: 7.3 (SD 2.0) and 32.5 (SD 4.9), respectively.

Burden analysis

More than half of family carers reported experiencing mild (35%) and moderate-severe (22%) burden due to their caregiving experience (Table 1). Family carers of highly dependent relatives with AMD were more likely to experience moderate-severe and mild burden after multivariable adjustment: OR 8.42 (95% CI 1.88-37.60) and 4.26 (95% CI 1.35-13.43), respectively (Table 2). Marginally significant associations were observed between the age and visual functioning of the care recipient with AMD and the level of burden experienced by family carers (Table 2). Younger carer age, older care recipient age, higher fatigue severity, high level of dependency on the carer and lower NEI VFQ-25 scores were significantly correlated with more carer burden (supplementary table 1). No statistically significant correlations were observed between carer burden scores and carer sex, patient sex, carer general quality of life scores (quality of life), carer and patient GHS scores (general health status, and carer GSE scores (general self-efficacy) (data not shown).

Depressive symptoms

Over one in five family carers (24%) demonstrated a significant presence of depressive symptoms as determined by the CESD-10 scale. Table 3 shows that family carers with higher levels of fatigue were more likely to experience depressive symptoms: OR 3.47 (95% CI 1.00-12.05). Conversely, each unit increase in family carer GQL scores was associated with 40%

reduced odds of experiencing depressive symptoms: OR 0.60 (95% CI 0.41-0.88). Statistically significant negative correlations between carer CESD-10 scores and carer GQL and GSE scores and care recipient NEI VFQ-25 scores were observed, and a significant positive correlation was shown between CESD-10 and carer FSS (supplementary table 2). No statistically significant correlations were observed between CESD-10 and carer age and sex, patient age and sex, carer and patient GHS scores, and level of dependency on the carer (data not shown).

Discussion

This novel study shows that family carers experience substantial levels of burden, depressive symptoms and fatigue when caring for relatives with AMD. The findings from this study are consistent with other studies that demonstrated poorer well-being of family carers of relatives with AMD[11]. Older carers of relatives with chronic disease are themselves biologically vulnerable to disease and are at substantial risk of developing health problems themselves, with studies showing family carers who experienced strain during their experience of providing care to be at greater risk of increased psychiatric morbidity[25,26]. This is also reflected by the finding that nearly a third of family carers in this study were providing care for their relatives with AMD while experiencing significant medical morbidity themselves including, cardiovascular disease, cerebrovascular disease, kidney disease, arthritis and diabetes. The continuous nature and stresses of providing care, together with burdensome physical and emotional demands on a population already at risk of declining health outcomes is a significant area of concern, not only due to declining health associated with the strain of providing care, but also because any compromise of carer health may in effect lead to inadequate provision of optimal care to the relative with AMD[11,27].

More than half of family carers of relatives with AMD reported experiencing mild or moderate-severe burden. In comparison, a cross-sectional study on caregiver burden for blind persons in India demonstrated a greater proportion of caregivers scoring ≥41 on the CBS (91.8%), that is, demonstrating substantial amounts of moderate to severe burden[28]. However, it is perhaps unsurprising that higher levels of burden were reported, given the more severe visual impairment of the population studied. Other areas of interest that should be considered for future research are differences in setting, availability of community support, socioeconomic status and cultural attitudes that may also influence perceived caregiver burden[28].

When compared with burden experienced by caregivers of patients with idiopathic Parkinson's disease, a greater proportion of family carers of patients with AMD experience moderate-severe burden (22%) than carers supporting family with early (10%) and late (~12%) stages of idiopathic Parkinson's disease[29]. In contrast, studies on caregivers for patients with stroke report higher levels of moderate-severe burden (~68%)[30]. Interestingly, a recent study on family and unpaid carers of older persons revealed that carers were at greater risk of experiencing burden when caring for patients with dementia with or without substantial disability, but not for those patients with substantial disability in the absence of dementia[31]. While patient functional impairment has been shown to be associated with higher levels of caregiver burden, this suggests that the additional challenges of caring for patients with dementia may be an issue that is not as relevant for the provision of care to patients with AMD[32].

The level of dependency that patients with AMD had on their family carers was independently associated with carer burden. This is in agreement with prior research by our group showing that family carers of patients with AMD that had high levels of dependency on them experience negative impacts such as high levels of emotional distress, as well as disruptions to their lifestyle and retirement plans[5]. Moreover, a systematic review of depression and burden among caregivers of patients with visual impairment found that greater hours of

supervision required and greater limitations in the patients' ability to carry out their activities of daily living, to be among the factors commonly associated with caregiver burden[33], a finding reflected in our study. It is likely that a high level of dependency on family carers may negatively impact the relationship between the carer and care recipient. This could be reflected in the considerable proportion of family carers of relatives with AMD in this study that report feeling frustrated, down and sad during their caregiving experience. Higher levels of dependency by the care recipient could be linked to loss of independence in the family carer due to a lack of time for one's own needs and leisure activities and this in turn could lead to feelings of burden[10]. Moreover, carers have previously reported feelings of guilt from inability to provide the constant and necessary care, with some carers experiencing feelings of being manipulated by the care recipient[5,10]. These feelings of burden due to the AMD caregiving experience can have profound implications on family carer health and well-being. Previous research conducted on the caregiving experience for elderly patients with chronic illnesses has demonstrated negative impacts on the carer's physical and psychological well-being, such as experiencing increased psychological distress, reduced engagement with preventative health behaviours, and disruptions to employment and increased financial stress[5, 10, 34]

In contrast, around one in ten family carers of relatives with AMD in this study experienced positive impacts of providing care, including feeling happier and more content with their lives, as well as feeling more optimistic and determined. It is possible that these differences of the caregiving experience among family carers may be related to pre-existing strong familial ties and/or relationships, or otherwise relationships that have strengthened since the need for family caregiving. Indeed, research into the role of partner relationship quality and reciprocity (that is, a mutual sense of fair exchange) has demonstrated benefits on caregiver wellbeing[35,36]. Another study examining the role of reciprocity in providing care for persons with dementia, chronic physical disability/illness, frailty from aging, and intellectual disability

showed an inverse relationship between reciprocity and self-esteem to caregiver burden[36]. These high-quality relationships may in fact provide the resources and means to alleviate the stress and burden that would otherwise be present during the provision of care[36]. As such, understanding the factors that determine relationship strength and how they can be targeted may be a potential area to address when aiming to improve equity in the family carer-care recipient dynamic.

Over one in five family carers of relatives with AMD demonstrated a significant presence of depressive symptoms in our study, and this is substantially higher that the global prevalence rates of ~6%[37]. Higher rates of depressive symptoms (~35%) have also been demonstrated in previous studies of family carers of patients with vision loss, along with significant associations between depressive symptoms and younger carer age and poorer patient visual acuity[38]. High rates (40%) of caregivers reporting depressive symptoms were found in a study on family carers of patients with Alzheimer's disease[39]. Higher levels of fatigue were shown to be predictive of family carers experiencing depressive symptoms in our study. This is perhaps unsurprising, given that fatigue and its symptoms are well-known symptoms/predictors of major depressive disorder in the general population[40]. Studies on the emotional well-being of carers of patients with AMD have previously reported increased rates of emotional distress, feelings of frustration, isolation and sadness[5,13,34].

Furthermore, poorer family carer quality of life was significantly associated with depressive symptoms. This association between quality of life and depressive symptoms is consistent with other cross-sectional and longitudinal studies involving older adults[41]. Poor quality of life limits one's ability to carry out their social and occupational activities[42,43]. Previous studies on caregiver quality of life have suggest that financial burden, lack of family/social support, distress and unmet needs are among the factors purportedly increasing the risk of depression and poor mental health outcomes[44-46].

Strengths of this study include the collection of rich and extensive outcome and covariate data from patients with AMD and their family carers, as well as the use of several validated scales for the assessment of carer and patient variables such as burden, depression, fatigue and visual functioning. However, findings of this study should be interpreted with caution. Due to the relatively small sample size, it is likely that the study was underpowered to detect modest associations, as well as limiting the generalisability of the results. Similarly, in the analyses small sample sizes accounted for large confidence intervals, providing less precise estimates of effect. The use of other tools such as the Barthel index for the measurement of care recipient dependency may have been potentially useful in providing a more accurate quantification of dependency. However, while this is a reliable measure of dependency, it is time consuming, given that direct observation of the person performing specific tasks is required. Also, we cannot discount residual confounding from factors that were not measured in our study such as the quality/ strength of the carer-care recipient relationship and other psychosocial measures such as spirituality and carer resilience. Moreover, the cross-sectional study design implemented was useful for investigating the relationships between various factors and health outcomes. However, this design limits our ability to draw conclusions about causality. Longitudinal and experimental analyses would allow for a better understanding of causality and the temporal interactions and relationships between variables in this study. As such, future studies of these types utilising larger population sets would be useful to affirm the findings of this study.

Conclusion

A substantial proportion of family carers of relatives with AMD experience significant burden and depressive symptoms. Family carers played a considerable role in the care of relatives with AMD, including aiding with access to medical care and assistance with care-recipient's ADLs.

Many carers self-reported experiencing feeling frustrated, depressive and sad. Levels of dependency and fatigue, as well as lower quality of life were independently associated with higher levels of burden and/or greater odds of depressive symptoms in family carers. Further research is required to affirm these conclusions regarding these predictors of burden and depressive symptoms in family carers of relatives with AMD.

a. Contributors

All authors—IJ, DT, GB, JG, KNP, AC, GL, PM and BG—provided inputs in study design. IJ, DT, JG, GB, PM and BG were involved in data collection and data analysis. IJ, JG and BG were responsible for publication writing. All authors reviewed and approved the final version of this manuscript.

b. Competing interests

None of the authors declared a conflict of interest.

c. Funding

This work was supported by the Australian National Health and Medical Research Council under a Partnership Project Grant (APP1115729); and the Macular Disease Foundation Australia.

d. Data sharing statement

Data are available upon reasonable request.

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Table 1. Study characteristics of family carers stratified by degree of burden experienced as measured by carer sex, age, general health status, FSS scores, CESD-10 scores, GSE scores, GQL scores, and care recipient sex, age, general health status and NEI VFQ-25 scores (n=96)

	Degree of burden			
Population characteristics	No/little burden (n=41)	Mild burden (n=33)	Moderate-severe burden (n=21)	*P*-value
Carer variables				
Female sex, *n* (%)	28 (68.3)	28 (84.9)	18 (85.7)	0.15
Age, yrs, *mean (SD)*	66.5 (15.6)	63.1 (13.1)	55.1 (10.4)	0.14
General health status				
Substantial comorbidity, *n* (%)	15 (36.6)	11 (33.3)	2 (9.5)	0.07
Fatigue severity scale score				
Problematic fatigue (≥4), *n* (%)	11 (26.8)	11 (33.3)	12 (57.1)	0.06
CESD-10 score				
Presence of depressive symptoms (≥10), *n* (%)	6 (14.6)	7 (21.2)	10 (47.6)	0.01

Total general self-efficacy scores, *mean (SD)*	33.0 (5.4)	32.7 (4.1)	31.0 (4.5)	0.32
Total general quality of life scores, *mean (SD)*	7.6 (1.7)	7.5 (1.8)	6.6 (2.0)	0.09
Patient variables				
Female sex, *n* (%)	25 (61.0)	20 (60.6)	17 (81.0)	0.23
Age, yrs, *mean (SD)*	81.0 (10.1)	84.5 (7.2)	84.4 (11.1)	0.15
General health status				
Substantial comorbidity, *n* (%)	19 (46.3)	15 (45.5)	14 (66.7)	0.25
Total NEI VFQ-25 scores, *mean (SD)*	62.7 (21.0)	53.6 (53.6)	38.6 (20.9)	<0.0001

Unadjusted *P* values from test of heterogeneity across the three burden categories. FSS – Fatigue Severity Scale; CESD-10 – Centre for Epidemiologic Studies Depression-10; GSE – generalised self-efficacy; GQL – General Quality of Life; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

Table 2. Association between selected family carer and care recipient with AMD variables with level of burden among family carers, presented as adjusted odds ratios (OR) and 95% confidence intervals (CI).

	Level of burden, OR (95% CI)*	
Factors	Mild	Moderate-severe
Care recipient age (each 1-unit increase)	1.03 (0.97–1.09)	0.99 (0.92-1.07)
NEI VFQ-25 score (each 1-unit increase)	1.00 (0.98–1.02)	0.96 (0.93-0.99)
High level of dependency on carer	4.26 (1.35–13.43)	8.42 (1.88-37.60)

*Logistic regression model (Generalized Logit Model) used the burden group 0-20 (no/little burden) as the reference category.

Table 3. Associations between selected variables and presence of depressive symptoms among family carers and care recipients with AMD, presented as adjusted odds ratios (OR) and 95% confidence intervals (CI).

Factor	Presence of depressive symptoms, OR (95% CI)
Family Carer	
Age (each 1-unit increase)	0.98 (0.91–1.04)
Female sex	0.58 (0.13–2.60)
General quality of life (each 1-unit increase)	0.60 (0.41–0.88)
Fatigue severity scale score (each 1-unit increase)	3.47 (1.00–12.05)
General self-efficacy (each 1-unit increase)	0.97 (0.86–1.10)
Care recipients with AMD	
Age (each 1-unit increase)	0.98 (0.90–1.05)
Female sex	1.29 (0.29–6.25)
General health status (each 1-unit increase)	1.84 (0.51–6.40)
NEI VFQ-25 (each 1-unit increase)	0.98 (0.95–1.01)

Supplementary tables

Table 1. Spearman correlation coefficients between burden group and carer age, FSS scores, and dependency, and care recipient age and NEI VFQ-25 scores among family carers of relatives with AMD (n=95)

Variable		Carer age	Patient age	Fatigue severity scale	Dependency	NEI VFQ-25
Carer burden	*r*	- 0.26	- 0.22	0.22	0.37	- 0.45
scores	*p*	0.0115	0.0349	0.0082	<0.0001	<0.0001

FSS – Fatigue Severity Scale; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

Supplementary table 2

Table 2. Pearson correlation coefficients between presence of depressive symptoms and carer variables (GQL scores, FSS scores, GSE scores) and care recipient NEI VFQ-25 scores among family carers of relatives with AMD (n=96)

Variable		General quality of life	Fatigue severity scale	General self-efficacy	NEI VFQ-25
CESD-10	*r*	- 0.46	0.34	- 0.21	- 0.26
	p	<0.0001	0.0008	0.0391	0.0121

CESD-10 – Centre for Epidemiologic Studies Depression-10; GQL – General Quality of Life; FSS – Fatigue Severity Scale; GSE – generalised self-efficacy; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

STROBE Statement

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **We have indicated in the title and abstract that this is a cross-sectional study.**	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **This is done.**	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **This is done.**	5
Objectives	3	State specific objectives, including any prespecified hypotheses **This is done.**	6
Methods			
Study design	4	Present key elements of study design early in the paper **This is done.**	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **This is done.**	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **This is shown in the '*Participants*' section of manuscript.**	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **This information is provided in the Methods section.**	7, 8, 9, 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 **This information is provided in the Methods section.**	7, 8, 9, 10
Bias	9	Describe any efforts to address potential sources of bias **N/A**	
Study size	10	Explain how the study size was arrived at **This is described in the Methods section**	6
Quantitative	11	Explain how quantitative variables were handled in the analyses. If	7, 8, 9, 10

variables		applicable, describe which groupings were chosen and why **This information is provided in the Methods section.**	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **This information is provided in the Methods section.**	10, 11
		(*b*) Describe any methods used to examine subgroups and interactions **This information is provided in the Methods section.**	10, 11
		(*c*) Explain how missing data were addressed **N/A**	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **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 **This is described in the Methods section**	6
		(b) Give reasons for non-participation at each stage **This is described in the Methods**	6
		(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 **See Table 1**	25
		(b) Indicate number of participants with missing data for each variable of interest **N/A**	
		(c) *Cohort study* —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study **This is reported in the Tables and Results section**	11, 12, 13, 25, 26, 27, 28
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 **See Tables 2-3 and Results section**	11, 12, 13, 25, 26, 27, 28
		(*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 **Included in Tables 2-3 and Supplementary files and Results section**	11, 12, 13, 25, 26, 27, 28, Supplementary files 1-2
Discussion			
Key results	18	Summarise key results with reference to study objectives **Paragraph 1, 2, 3 and 6 of the Discussion section**	13, 14, 15, 16, 17, 18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Strengths and limitations are discussed in Discussion section – page 16 and 17**	16, 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **This is provided in the Discussion**	16, 17
Generalisability	21	Discuss the generalisability (external validity) of the study results **Provided in the Discussion**	16, 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 **This information is provided on page 3 after the Abstract**	3

*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.

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.

BMJ Open

Cross-sectional study evaluating burden and depressive symptoms in family carers of persons with age-related macular degeneration in Australia

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-048658.R2
Article Type:	Original research
Date Submitted by the Author:	12-Aug-2021
Complete List of Authors:	Jin, Ivan; The University of Sydney Tang, Diana; The University of Sydney Gengaroli, Jessica; Australian College of Applied Psychology Nicholson Perry, Kathryn; Australian College of Applied Psychology Burlutsky, George; Melbourne University Craig, Ashley; University of Sydney, Northern Clinical School Liew, Gerald; University of Sydney, Centre for Vision Research Mitchell, Paul; University of Sydney, Centre for Vision Research Gopinath, Bamini; Macquarie University,
Primary Subject Heading:	Ophthalmology
Secondary Subject Heading:	Epidemiology, Mental health, Public health
Keywords:	EPIDEMIOLOGY, MENTAL HEALTH, Medical retina < OPHTHALMOLOGY, PUBLIC HEALTH

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Cross-sectional study evaluating burden and depressive symptoms in family carers of persons with age-related macular degeneration in Australia

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Abstract

Objectives: We aimed to analyse the degree of carer burden and depressive symptoms in family carers of persons with age-related macular degeneration (AMD) and explore the factors independently associated with carer burden and depressive symptoms.

Methods: Cross-sectional study using self- and interviewer-administered surveys, involving 96 family carer-care recipient pairs. Participants were identified from tertiary ophthalmology clinics in Sydney, Australia, as well as the Macular Disease Foundation of Australia database. Logistic regression, Pearson and Spearman correlation analyses were used to investigate associations of explanatory factors, (family caregiving experience, carer fatigue, carer quality of life and care recipient level of dependency) with study outcomes - carer burden and depressive symptoms.

Results: Over one in two family carers reported experiencing mild or moderate-severe burden. More than one in five and more than one in three family carers experienced depressive symptoms and substantial fatigue, respectively. High level of care recipient dependency was associated with greater odds of moderate-severe and mild carer burden, multivariable-adjusted OR 8.42 (95% CI 1.88-37.60) and OR 4.26 (95% CI 1.35-13.43) respectively. High levels of fatigue were associated with 3-fold greater odds of the carer experiencing depressive symptoms, multivariable-adjusted OR 3.47 (95% CI 1.00-12.05).

Conclusions: A substantial degree of morbidity is observed in family carers during the caregiving experience for patients with AMD. Level of dependency on the family carer and fatigue were independently associated with family carer burden and depressive symptoms.

Strengths and limitations of this study

- The study design and method of surveying allowed for the collection of rich and extensive data from patients with AMD and their family carers.
- Several validated scales for the assessment of both carer and patient variables were used, including those for burden, depression, fatigue and visual functioning.
- Study participants were recruited from only one state in Australia
- Due to the relatively small sample size, the study is likely to be underpowered for detecting modest associations

Patient consent

Obtained.

Ethics approval

Ethics approval was obtained from The University of Sydney Human Research Ethics Committee (ID# - 2016/793).

Acknowledgements

The authors thank all individuals for their time and participation in the study.

Introduction

Age-related macular degeneration (AMD) is a chronic and progressive disorder of the macula[1] and is the leading cause of blindness and low vision in Australia, directly affecting more than 1 million persons[2,3]. The effects of vision impairment in AMD are not limited to declining visual function, with several studies showing that AMD affects multiple health domains and leads to significant emotional distress, poorer quality of life and reduced functional independence[4,5]. For many patients, the ongoing nature of a chronic illness like AMD is such that it requires the provision of continuous physical and emotional care beyond the scope of what can be currently provided by hospitals or other institutions[6,7]. Family carers of relatives with AMD are often expected to provide a high standard of care despite not receiving formal training and adequate support for this role[8,9]. Surveys on the perceptions of family carers of relatives with AMD in their role as informal carers, demonstrate experiences of significant psychological distress, with the negative impacts of caring extending to increased financial stress, disruptions to lifestyle and retirement plans, and added strain on the relationship between carer and care recipient[5,10]. Moreover, previous studies based in the UK have shown that caregivers of patients with AMD experience burden levels comparable to those caring for persons with rheumatoid arthritis and multiple sclerosis[11]. Additionally, comorbidity has been shown to be associated with a higher degree of caregiver burden, as demonstrated in other caregiving settings such as for patients with dementia[12]. Furthermore, a significant degree of psychological distress has been reported in caregivers of legally blind patients, with one such study reporting more than a third of caregivers experiencing depression[13]. Previous research conducted by our group on caregiving for AMD have demonstrated that the level of caregiver dependence and the presence of multiple chronic illnesses in the care-recipient were independent predictors of psychological distress[14].

Clearly, the impacts of AMD are far-reaching, with significant influence on family, friends and carers, as well as substantial cost to society[3,15]. However, currently there exists little literature reporting on the level and factors of burden and depressive symptoms experienced by family carers of relatives with AMD. As such, the key aims of this cross-sectional study were to: 1) Analyse the degree of carer burden and depressive symptoms in family carers of persons with AMD; and 2) Explore the factors that were independently associated with carer burden and depressive symptoms.

Methods

Participants

Participants for this study were recruited as a part of a randomised controlled trial implementing a novel multi-component intervention targeting the drivers of stress and burden in family carers of patients with AMD. This study analysed a total of 96 patients with AMD and 96 of their family carers who were examined at baseline (pre-intervention). Recruitment of participants occurred between January 2017 to May 2020 across multiple ophthalmology practices in Sydney, Australia, as well as via the Macular Disease Foundation Australia (MDFA) database of members. The inclusion criteria for eligible family carers participating in this study were: adults aged more than 18 years old; family carer of a relative with AMD; willing to engage in a 10-week cognitive behavioural therapy intervention over a 3-month period; and sufficient English fluency to effectively engage in the intervention. All participants in this study gave written informed consent. Ethics approval was obtained from The University of Sydney Human Research Ethics Committee (ID# - 2016/793). Information on baseline study participant characteristics were obtained via surveys of family carers and their relatives with AMD, completed on-site during clinic visits or at home either independently or with help from the study coordinator e.g. due to limitations imposed by poor vision.

Patient and Public Involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

Sociodemographic information and medical history

All participants (carers and care recipients with AMD) provided sociodemographic information including: age, sex, education level and marital status. They also self-reported any medical conditions such as: heart attacks; angina (without myocardial infarction); any other cardiac conditions; strokes or transient ischaemic attacks; high blood pressure; high cholesterol; diabetes or prediabetes; kidney disease; arthritis; hearing loss; and visual impairment. This information was used to assess the general health status (GHS) of each participant. Participants who reported 3 or more health conditions were considered as having substantial comorbidity and received a score of 1, whereas those with fewer than 3 health conditions received a score of 0.

Carer variables

Family carers were asked to provide details about the patient with AMD that they cared for such as whether they were the sole caregiver of the patient; the type of caregiving duties performed and the hours of care (per day) they provided to the care recipient with AMD. This comprised of 21 questions detailing caregiving duties as they applied to typical activities of daily living and instrumental activities of daily living for the patient with AMD, including exercise and/or sport, cooking and preparing food, cleaning, reading, personal grooming, using public transport, driving and more. Each question was scored reflecting the degree of help given for each activity *(0=no help or little help given, 1=moderate amount of help given,*

2=high amount of help given, 3=not applicable). Additional information on family carers was determined by administering several validated instruments and scales as detailed below:

(i) Carer burden. The Caregiver Burden Scale (CBS) is a 22-item questionnaire originally developed for assessment of perceived family carer burden in caring for patients with dementia[16,17]. Each question was scored on a 5-point Likert-type scale *(0=never, 1=rarely, 2=sometimes, 3=quite frequently, 4=always)*, reflecting the frequency of family carers' feelings when taking care of their family member. The total burden score calculated for each family carer was used to stratify levels of burden into 3 categories, with higher scores indicating higher levels of burden (*0-20=no/little burden, 21-40=mild burden, ≥41=moderate-severe burden*). [16] The CBS is a reliable measure with a Cronbach's alpha of 0.92[18].

(ii) Depressive symptoms. The short form of the Centre for Epidemiologic Studies Depression (CESD-10) scale is a 10-item questionnaire and was used to screen for symptoms of depression[19]. Each question gauges the frequency of a family carer experiencing certain symptoms of depression per week and is scored on a 4-point Likert-type scale *(0 = rarely or none of the time (<1 day), 1=some or a little of the time (1-2 days), 2=occasionally or a moderate amount of the time (3-4 days), 3=most or all of the time (5-7 days)*. A total CESD-10 score of 10 or more indicates significant presence of depressive symptoms, as reported by previous research evaluating the validity of the CESD-10 scale[19]. The CESD-10 is a validated and reliable measure with a Cronbach's alpha of 0.80[19,20].

(iii) Fatigue. The Fatigue Severity Scale (FSS) is a 9-item questionnaire used frequently to assess the degree of impact that fatigue has on an individual's activities and physical functioning[21]. Participants were asked to respond to statements about how much fatigue

impacted their ability to function on a scale of 1 *(disagree)* to 7 *(agree)*. Previous studies have shown mean (SD) FSS scores for healthy individuals to be 2.3 (0.7)[21]. Mean FSS scores of 4 or more were categorised as having problematic fatigue. The FSS is a validated and reliable measure with a Cronbach's alpha of 0.88[21].

(iv) Self-efficacy. The General self-efficacy (GSE) scale is a 10-item questionnaire shown to be effective at measuring one's beliefs of overall ability to succeed in specific situations[22]. The degree of how much a family carer agreed with each statement was measured using a 4-point Likert-type scale *(0=not true, 1=hardly true, 2=moderately true, 3=exactly true)*. Higher total GSE scores indicate higher self-efficacy.

(v) Dependency. Carers were asked to quantify the level of dependence their family member with AMD had on them since their diagnosis using a 5-point Likert-type scale *(1=not at all dependent, 2=somewhat dependent, 3=moderately dependent, 4 = very dependent, 5 = extremely dependent)*. Scores 3 or more were interpreted as an indication of high dependency on the family carer *(1-2 = low dependency, 3-5 = high dependency)*.

(vi) Quality of life. Carer's rated their general quality of life (GQL) on a linear scale from 0 *(poor quality of life)* to 10 *(excellent quality of life)*.

Care recipients with AMD

The National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25) was completed by care recipients, and is a reliable and validated tool used to measure status of vision-related health impairment most relevant to patients with chronic eye conditions[23]. Questions in the

NEI VFQ-25 were used to determine the extent of how visual disability and symptoms negatively impacts the patient's ability to function, well-being and efficacy in achieving vision-related tasks. The NEI VFQ-25 is comprised of 12 subscales, assessing general vision, near and distance vision, vision-related difficulty with activities, vision-related driving problems, eye pain, colour vision, dependency, impact on social functioning, mental health and general health[23]. Scores recorded in the original response category for each question were recoded to a scale between 0-100 in accordance with the NEI VFQ-25 scoring algorithm, with higher scores indicating greater vision-related well-being.

Statistical analysis

SAS statistical software (SAS Institute, NC, v9.4) was used for the statistical analysis, including t-tests, chi-squared tests, F-test and logistical regression. We analysed caregiver burden as a categorical variable based on the previous literature by Zarit et al.[16] and the generalised logits model was used for carer burden, given that it is a three-level categorical variable[24]. A binary logistic regression was used for the study outcome of depressive symptoms as it is a two-level variable. For all models, a stepwise selection method was used.

Predictor variables assessed for both these study outcomes were: carer age, carer sex, carer general quality of life, carer general health status, fatigue severity, general self-efficacy, level of dependency on the carer, patient age, patient sex, patient general health status and patient NEI VFQ-25 scores. The CORR procedure was used to compute the Pearson correlations and Spearman rank-order correlations between presence of depressive symptoms (CESD-10 score) and the following variables: patient age and sex, and carer variables (age, sex, general quality of life scores, fatigue severity scale scores, carer and patient general health status, general self-efficacy, level of dependency on the carer and NEI VFQ-25 scores). The

significance level was <0.05. Checks for multicollinearity did not return any confirmation of multicollinearity occurring.

Results

AMD caregiving experience and health-related variables

The majority of family carers (91%) were aged 50 years and over, with family carers aged 65 years or older making up 54% of the sample. The proportion of females was 78% and 66% among family carers and care recipients with AMD, respectively. Of the 96 family carers in this study, 75% were the sole carer of the patients with AMD, with 43% reporting that the family member they cared for was highly dependent on them. Family carers played a considerable role in helping their relatives access medical care, with 91% accompanying their relatives to their ophthalmology appointments where the majority of relatives with AMD (79%) were receiving anti-VEGF injections. In terms of how often help was provided to relatives with AMD, 61% of family carers reported providing help for 7 days a week on average, with 45% reporting either spending >8 hours per day with them or living together with the care recipient. The main caregiving duties where carers provided moderate to high amounts of help included cooking (57%), cleaning (60%) and help with leaving the house (70%).

Substantial amounts of fatigue were experienced by 36% of family carers as indicated by scores of 4 or higher on the fatigue severity scale, and a considerable degree of general health comorbidities was reported by 29% of family carers. The mean quality of life and general self-efficacy scores among the family carers in this study were: 7.3 (SD 2.0) and 32.5 (SD 4.9), respectively.

Burden analysis

More than half of family carers reported experiencing mild (35%) and moderate-severe (22%) burden due to their caregiving experience (Table 1). Family carers of highly dependent relatives with AMD were more likely to experience moderate-severe and mild burden after multivariable adjustment: OR 8.42 (95% CI 1.88-37.60) and 4.26 (95% CI 1.35-13.43), respectively (Table 2). Marginally significant associations were observed between the age and visual functioning of the care recipient with AMD and the level of burden experienced by family carers (Table 2). Younger carer age, older care recipient age, higher fatigue severity, high level of dependency on the carer and lower NEI VFQ-25 scores were significantly correlated with more carer burden (supplementary table 1). No statistically significant correlations were observed between carer burden scores and carer sex, patient sex, carer general quality of life scores (quality of life), carer and patient GHS scores (general health status, and carer GSE scores (general self-efficacy) (data not shown).

Depressive symptoms

Over one in five family carers (24%) demonstrated a significant presence of depressive symptoms as determined by the CESD-10 scale (i.e. total score 10 or more). Table 3 shows that family carers with higher levels of fatigue were more likely to experience depressive symptoms: OR 3.47 (95% CI 1.00-12.05). Conversely, each unit increase in family carer GQL scores was associated with 40% reduced odds of experiencing depressive symptoms: OR 0.60 (95% CI 0.41-0.88). Statistically significant negative correlations between carer CESD-10 scores and carer GQL and GSE scores and care recipient NEI VFQ-25 scores were observed, and a significant positive correlation was shown between CESD-10 and carer FSS (supplementary table 2). No statistically significant correlations were observed between CESD-10 and carer age and sex, patient age and sex, carer and patient GHS scores, and level of dependency on the carer (data not shown).

Discussion

This novel study shows that family carers experience substantial levels of burden, depressive symptoms and fatigue when caring for relatives with AMD. The findings from this study are consistent with other studies that demonstrated poorer well-being of family carers of relatives with AMD[11]. Older carers of relatives with chronic disease are themselves biologically vulnerable to disease and are at substantial risk of developing health problems themselves, with studies showing family carers who experienced strain during their experience of providing care to be at greater risk of increased psychiatric morbidity[25,26]. This is also reflected by the finding that nearly a third of family carers in this study were providing care for their relatives with AMD while experiencing significant medical morbidity themselves including, cardiovascular disease, cerebrovascular disease, kidney disease, arthritis and diabetes. The continuous nature and stresses of providing care, together with burdensome physical and emotional demands on a population already at risk of declining health outcomes is a significant area of concern, not only due to declining health associated with the strain of providing care, but also because any compromise of carer health may in effect lead to inadequate provision of optimal care to the relative with AMD[11,27].

More than half of family carers of relatives with AMD reported experiencing mild or moderate-severe burden. In comparison, a cross-sectional study on caregiver burden for blind persons in India demonstrated a greater proportion of caregivers scoring ≥41 on the CBS (91.8%), that is, demonstrating substantial amounts of moderate to severe burden[28]. However, it is perhaps unsurprising that higher levels of burden were reported, given the more severe visual impairment of the population studied. Other areas of interest that should be considered for future research are differences in setting, availability of community support, socioeconomic status and cultural attitudes that may also influence perceived caregiver burden[28].

When compared with burden experienced by caregivers of patients with idiopathic Parkinson's disease, a greater proportion of family carers of patients with AMD experience moderate-severe burden (22%) than carers supporting family with early (10%) and late (~12%) stages of idiopathic Parkinson's disease[29]. In contrast, studies on caregivers for patients with stroke report higher levels of moderate-severe burden (~68%)[30]. Interestingly, a recent study on family and unpaid carers of older persons revealed that carers were at greater risk of experiencing burden when caring for patients with dementia with or without substantial disability, but not for those patients with substantial disability in the absence of dementia[31]. While patient functional impairment has been shown to be associated with higher levels of caregiver burden, this suggests that the additional challenges of caring for patients with dementia may be an issue that is not as relevant for the provision of care to patients with AMD[32].

The level of dependency that patients with AMD had on their family carers was independently associated with carer burden. This is in agreement with prior research by our group showing that family carers of patients with AMD that had high levels of dependency on them experience negative impacts such as high levels of emotional distress, as well as disruptions to their lifestyle and retirement plans[5]. Moreover, a systematic review of depression and burden among caregivers of patients with visual impairment found that greater hours of supervision required and greater limitations in the patients' ability to carry out their activities of daily living, to be among the factors commonly associated with caregiver burden[33], a finding reflected in our study. It is likely that a high level of dependency on family carers may negatively impact the relationship between the carer and care recipient. Higher levels of dependency by the care recipient could be linked to loss of independence in the family carer due to a lack of time for one's own needs and leisure activities and this in turn could lead to feelings of burden[10]. Moreover, carers have previously reported feelings of guilt from inability to provide the constant and necessary care, with some carers experiencing feelings of being

manipulated by the care recipient[5,10]. These feelings of burden due to the AMD caregiving experience can have profound implications on family carer health and well-being. Previous research conducted on the caregiving experience for elderly patients with chronic illnesses has demonstrated negative impacts on the carer's physical and psychological well-being, such as experiencing increased psychological distress, reduced engagement with preventative health behaviours, and disruptions to employment and increased financial stress[5, 10, 34]

In contrast, around one in ten family carers of relatives with AMD in this study experienced positive impacts of providing care, including feeling happier and more content with their lives, as well as feeling more optimistic and determined. It is possible that these differences of the caregiving experience among family carers may be related to pre-existing strong familial ties and/or relationships, or otherwise relationships that have strengthened since the need for family caregiving. Indeed, research into the role of partner relationship quality and reciprocity (that is, a mutual sense of fair exchange) has demonstrated benefits on caregiver wellbeing[35,36]. Another study examining the role of reciprocity in providing care for persons with dementia, chronic physical disability/illness, frailty from aging, and intellectual disability showed an inverse relationship between reciprocity and self-esteem to caregiver burden[36]. These high-quality relationships may in fact provide the resources and means to alleviate the stress and burden that would otherwise be present during the provision of care[36]. As such, understanding the factors that determine relationship strength and how they can be targeted may be a potential area to address when aiming to improve equity in the family carer-care recipient dynamic.

Over one in five family carers of relatives with AMD demonstrated a significant presence of depressive symptoms in our study, and this is substantially higher that the global prevalence rates of ~6%[37]. Higher rates of depressive symptoms (~35%) have also been demonstrated in previous studies of family carers of patients with vision loss, along with significant associations

between depressive symptoms and younger carer age and poorer patient visual acuity[38]. High rates (40%) of caregivers reporting depressive symptoms were found in a study on family carers of patients with Alzheimer's disease[39]. Higher levels of fatigue were shown to be predictive of family carers experiencing depressive symptoms in our study. This is perhaps unsurprising, given that fatigue and its symptoms are well-known symptoms/predictors of major depressive disorder in the general population[40]. Studies on the emotional well-being of carers of patients with AMD have previously reported increased rates of emotional distress, feelings of frustration, isolation and sadness[5,13,34].

Furthermore, poorer family carer quality of life was significantly associated with depressive symptoms. This association between quality of life and depressive symptoms is consistent with other cross-sectional and longitudinal studies involving older adults[41]. Poor quality of life limits one's ability to carry out their social and occupational activities[42,43]. Previous studies on caregiver quality of life have suggest that financial burden, lack of family/social support, distress and unmet needs are among the factors purportedly increasing the risk of depression and poor mental health outcomes[44-46].

Strengths of this study include the collection of rich and extensive outcome and covariate data from patients with AMD and their family carers, as well as the use of several validated scales for the assessment of carer and patient variables such as burden, depression, fatigue and visual functioning. However, findings of this study should be interpreted with caution. Due to the relatively small sample size, it is likely that the study was underpowered to detect modest associations, as well as limiting the generalisability of the results. Similarly, in the analyses small sample sizes accounted for large confidence intervals, providing less precise estimates of effect. The use of other tools such as the Barthel index for the measurement of care recipient dependency may have been potentially useful in providing a more accurate quantification of dependency. However, while this is a reliable measure of dependency, it is

time consuming, given that direct observation of the person performing specific tasks is required. Also, we cannot discount residual confounding from factors that were not measured in our study such as the quality/ strength of the carer-care recipient relationship and other psychosocial measures such as spirituality and carer resilience. Moreover, the cross-sectional study design implemented was useful for investigating the relationships between various factors and health outcomes. However, this design limits our ability to draw conclusions about causality. Longitudinal and experimental analyses would allow for a better understanding of causality and the temporal interactions and relationships between variables in this study. As such, future studies of these types utilising larger population sets would be useful to affirm the findings of this study.

Conclusion

A substantial proportion of family carers of relatives with AMD experience significant burden and depressive symptoms. Family carers played a considerable role in the care of relatives with AMD, including aiding with access to medical care and assistance with care-recipient's ADLs. Levels of dependency and fatigue, as well as lower quality of life were independently associated with higher levels of burden and/or greater odds of depressive symptoms in family carers. Further research is required to affirm these conclusions regarding these predictors of burden and depressive symptoms in family carers of relatives with AMD.

a. Contributors

All authors—IJ, DT, GB, JG, KNP, AC, GL, PM and BG—provided inputs in study design. IJ, DT, JG, GB, PM and BG were involved in data collection and data analysis. IJ, JG and BG were responsible for publication writing. All authors reviewed and approved the final version of this manuscript.

b. Competing interests

None of the authors declared a conflict of interest.

c. Funding

This work was supported by the Australian National Health and Medical Research Council under a Partnership Project Grant (APP1115729); and the Macular Disease Foundation Australia.

d. Data sharing statement

Data are available upon reasonable request.

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Table 1. Study characteristics of family carers stratified by degree of burden experienced as measured by carer sex, age, general health status, FSS scores, CESD-10 scores, GSE scores, GQL scores, and care recipient sex, age, general health status and NEI VFQ-25 scores (n=96)

	Degree of burden			
Population characteristics	No/little burden (n=41)	Mild burden (n=33)	Moderate-severe burden (n=21)	*P*-value
Carer variables				
Female sex, *n* (%)	28 (68.3)	28 (84.9)	18 (85.7)	0.15
Age, yrs, *mean (SD)*	66.5 (15.6)	63.1 (13.1)	55.1 (10.4)	0.14
General health status				
Substantial comorbidity, *n* (%)	15 (36.6)	11 (33.3)	2 (9.5)	0.07
Fatigue severity scale score				
Problematic fatigue (≥4), *n* (%)	11 (26.8)	11 (33.3)	12 (57.1)	0.06
CESD-10 score				
Presence of depressive symptoms (≥10), *n* (%)	6 (14.6)	7 (21.2)	10 (47.6)	0.01

Total general self-efficacy scores, *mean (SD)*	33.0 (5.4)	32.7 (4.1)	31.0 (4.5)	0.32
Total general quality of life scores, *mean (SD)*	7.6 (1.7)	7.5 (1.8)	6.6 (2.0)	0.09
Patient variables				
Female sex, *n* (%)	25 (61.0)	20 (60.6)	17 (81.0)	0.23
Age, yrs, *mean (SD)*	81.0 (10.1)	84.5 (7.2)	84.4 (11.1)	0.15
General health status				
Substantial comorbidity, *n* (%)	19 (46.3)	15 (45.5)	14 (66.7)	0.25
Total NEI VFQ-25 scores, *mean (SD)*	62.7 (21.0)	53.6 (53.6)	38.6 (20.9)	<0.0001

Unadjusted *P* values from test of heterogeneity across the three burden categories. FSS – Fatigue Severity Scale; CESD-10 – Centre for Epidemiologic Studies Depression-10; GSE – generalised self-efficacy; GQL – General Quality of Life; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

Table 2. Association between selected family carer and care recipient with AMD variables with level of burden among family carers, presented as adjusted odds ratios (OR) and 95% confidence intervals (CI).

	Level of burden, OR (95% CI)*	
Factors	Mild	Moderate-severe
Care recipient age (each 1-unit increase)	1.03 (0.97–1.09)	0.99 (0.92-1.07)
NEI VFQ-25 score (each 1-unit increase)	1.00 (0.98–1.02)	0.96 (0.93-0.99)
High level of dependency on carer	4.26 (1.35–13.43)	8.42 (1.88-37.60)

*Logistic regression model (Generalized Logit Model) used the burden group 0-20 (no/little burden) as the reference category.

Table 3. Associations between selected variables and presence of depressive symptoms among family carers and care recipients with AMD, presented as adjusted odds ratios (OR) and 95% confidence intervals (CI).

Factor	Presence of depressive symptoms, OR (95% CI)
Family Carer	
Age (each 1-unit increase)	0.98 (0.91–1.04)
Female sex	0.58 (0.13–2.60)
General quality of life (each 1-unit increase)	0.60 (0.41–0.88)
Fatigue severity scale score (each 1-unit increase)	3.47 (1.00–12.05)
General self-efficacy (each 1-unit increase)	0.97 (0.86–1.10)
Care recipients with AMD	
Age (each 1-unit increase)	0.98 (0.90–1.05)
Female sex	1.29 (0.29–6.25)
General health status (each 1-unit increase)	1.84 (0.51–6.40)
NEI VFQ-25 (each 1-unit increase)	0.98 (0.95–1.01)

Supplementary tables

Table 1. Spearman correlation coefficients between burden group and carer age, FSS scores, and dependency, and care recipient age and NEI VFQ-25 scores among family carers of relatives with AMD (n=95)

Variable		Carer age	Patient age	Fatigue severity scale	Dependency	NEI VFQ-25
Carer burden scores	*r*	- 0.26	- 0.22	0.22	0.37	- 0.45
	p	0.0115	0.0349	0.0082	<0.0001	<0.0001

FSS – Fatigue Severity Scale; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

Supplementary table 2

Table 2. Pearson correlation coefficients between presence of depressive symptoms and carer variables (GQL scores, FSS scores, GSE scores) and care recipient NEI VFQ-25 scores among family carers of relatives with AMD (n=96)

Variable		General quality of life	Fatigue severity scale	General self-efficacy	NEI VFQ-25
CESD-10	*r*	- 0.46	0.34	- 0.21	- 0.26
	p	<0.0001	0.0008	0.0391	0.0121

CESD-10 – Centre for Epidemiologic Studies Depression-10; GQL – General Quality of Life; FSS – Fatigue Severity Scale; GSE – generalised self-efficacy; NEI VFQ-25 – National Eye Institute Visual Functioning Questionnaire-25

STROBE Statement

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **We have indicated in the title and abstract that this is a cross-sectional study.**	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **This is done.**	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **This is done.**	5
Objectives	3	State specific objectives, including any prespecified hypotheses **This is done.**	6
Methods			
Study design	4	Present key elements of study design early in the paper **This is done.**	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **This is done.**	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **This is shown in the '*Participants*' section of manuscript.**	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **This information is provided in the Methods section.**	7, 8, 9, 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 **This information is provided in the Methods section.**	7, 8, 9, 10
Bias	9	Describe any efforts to address potential sources of bias **N/A**	
Study size	10	Explain how the study size was arrived at **This is described in the Methods section**	6
Quantitative	11	Explain how quantitative variables were handled in the analyses. If	7, 8, 9, 10

variables		applicable, describe which groupings were chosen and why **This information is provided in the Methods section.**	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **This information is provided in the Methods section.**	10, 11
		(*b*) Describe any methods used to examine subgroups and interactions **This information is provided in the Methods section.**	10, 11
		(*c*) Explain how missing data were addressed **N/A**	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **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 **This is described in the Methods section**	6
		(b) Give reasons for non-participation at each stage **This is described in the Methods**	6
		(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 **See Table 1**	25
		(b) Indicate number of participants with missing data for each variable of interest **N/A**	
		(c) *Cohort study* —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study **This is reported in the Tables and Results section**	11, 12, 13, 25, 26, 27, 28
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 **See Tables 2-3 and Results section**	11, 12, 13, 25, 26, 27, 28
		(*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 **Included in Tables 2-3 and Supplementary files and Results section**	11, 12, 13, 25, 26, 27, 28, Supplementary files 1-2
Discussion			
Key results	18	Summarise key results with reference to study objectives **Paragraph 1, 2, 3 and 6 of the Discussion section**	13, 14, 15, 16, 17, 18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Strengths and limitations are discussed in Discussion section – page 16 and 17**	16, 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **This is provided in the Discussion**	16, 17
Generalisability	21	Discuss the generalisability (external validity) of the study results **Provided in the Discussion**	16, 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 **This information is provided on page 3 after the Abstract**	3

*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.

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.