Journal of Psychosomatic Research 169 (2023) 111325

Contents lists available at ScienceDirect

Journal of Psychosomatic Research

journal homepage: www.elsevier.com/locate/jpsychores

Prosocial behaviour helps to ease physical pain: Longitudinal evidence from Britain

Lucía Macchia [a,*], Justin Farmer [b], Laura D. Kubzansky [b]

[a] City, University of London, United Kingdom
[b] Harvard T.H. Chan School of Public Health, United States of America

ARTICLE INFO

Keywords:
Physical pain
Prosocial behaviour
Health
Donating
Volunteering

ABSTRACT

Objective: Prior studies suggest that prosocial behaviour can lead to better mental and physical health. Yet little is known about whether engaging in prosocial behaviour contributes to reducing physical pain. The objective of this study is to investigate longitudinal associations of two prosocial behaviours, donating money to charity and/or volunteering time to an organisation, with pain.

Methods: Data are from the United Kingdom Household Longitudinal Survey (UKHLS, approximate $N = 48{,}000$ individuals). Both prosocial behaviours were assessed in 2011 and pain was assessed annually through 2020, according to the extent to which it interfered with respondents' ability to do work. Using a prospective longitudinal study design, linear mixed models examined associations of each prosocial behaviour separately and both combined on pain interference across 10 years of follow-up adjusting for a broad range of covariates including demographics, initial health status, and depression.

Results: People who did versus did not donate or volunteer reported lower pain interference over 10 years of follow-up (donating $b = -0.059$, $p < 0.001$; volunteering $b = -0.086$, $p < 0.001$). Individuals who donated more versus less money reported lower pain interference although volunteering more hours was not associated with lower pain interference. Finally, findings suggested that engaging in both donating and volunteering versus neither was associated with lower pain interference over follow-up.

Conclusion: There is a longitudinal association between donating money to charity and/or volunteering time to an organisation with pain interference with work. Understanding factors that help to reduce pain is relevant for the design of public health policies.

Physical pain is one of the primary reasons people visit the emergency room [1]. Approximately 9 million people live with chronic pain in the United Kingdom and musculoskeletal pain alone accounts for 30% of medical consultations [2]. Physical pain adversely affects quality of life, including mental health [3], productivity at work [4], and people's experience of family and workplace [5]. Prior work considering the role of psychosocial factors in physical pain shows higher pain is associated with negative emotions [6,7], lack of control [8], distress due to economic recessions [9,10], loneliness and social isolation [11,12], and discrimination [13]. However, little research has explored factors that might protect against experiencing physical pain. Identifying and understanding such factors is crucial to improving individuals' quality of life and alleviating burden on the healthcare system.

Prosocial behaviour - behaviour that benefits others [14] - has been identified as health protective [15]. Various prosocial behaviours have been studied in relation to mental and physical health, namely, helping, sharing, donating, cooperating, volunteering, and acting kindly with others [16]. Prior research shows prosocial spending (i.e., spending money on others vs on oneself) is a strong predictor of happiness [17] and donating money to charity is associated with greater life satisfaction [18]. People asked to donate money to charity exhibited increased activation in brain areas linked to pleasure and reward [19]. Moreover, spending money on others was found to be associated with improved cardiovascular health [20].

Prior work has also demonstrated volunteering time is beneficial for mental and physical health. Using longitudinal data from older adults, Mak et al. [21] found volunteering was associated with lower mental distress and better health-related quality of life. A recent review of

* Corresponding author at: City, University of London, School of Health and Psychological Sciences, Rhind Building, St John St, London EC1R 0JD, United Kingdom.
E-mail address: lucia.macchia@city.ac.uk (L. Macchia).

https://doi.org/10.1016/j.jpsychores.2023.111325
Received 19 November 2022; Received in revised form 27 March 2023; Accepted 27 March 2023
Available online 3 April 2023

studies examining links between volunteering and health in later life, concluded mechanisms underlying these associations may include expanded social networks and social support, greater sense of meaning in life, alleviation of stress, and enhanced biophysiological processes [22]. A common concern with many of these studies is whether better health leads to more volunteering behaviour rather than the reverse. However, a recent outcome-wide longitudinal study found people who volunteered over 100 versus 0 hours per year at study baseline subsequently experienced higher levels of optimism, lower loneliness, and lower risk of mortality and physical function limitations among other outcomes over four years of follow-up [23,24]. In a related study, Burr et al. [25] found people who reported volunteering and helping others informally had lower subsequent risk of developing cardiovascular disease over 10 years of follow-up [see also 26].

Prior studies have also found a consistent link between prosocial behaviour and risk of mortality [15,25]. For instance, people who do versus do not volunteer tend to have lower risk of mortality even after controlling for physical activities and having a hobby [27]. Furthermore, Konrath et al. [28] found when volunteering was driven by other-oriented versus self-oriented motives an even lower risk of mortality was evident.

Despite the toll of pain and the burden on the healthcare system, the association between prosocial behaviour and pain has not received extensive attention. One exception is a non-randomized study of seven chronic pain patients who completed a pain management programme which found chronic pain levels decreased after individuals engaged in volunteering [29]. In a large scale cross-sectional study of 33,924 US adults, Qu [30] found that people who did versus did not volunteer reported lower pain. Yet, no research has examined the longitudinal association of different types of prosocial behaviour with physical pain in the general population using a nationally representative sample (but see [39] for longitudinal studies of pain with other outcomes). The present study addresses this question using data from a large longitudinal study with 10 years of follow-up and annual assessments of pain. Specifically, this study explores the association between prosocial behaviour, represented by donating money to charity and volunteering time to an organisation, and subsequent experiences of pain. We hypothesized individuals who do versus do not donate money to charity and volunteer time to an organisation would report less pain interference. We also hypothesized that people who donate more money and who volunteer a greater number of hours would report lower pain interference. Given donating and volunteering may not necessarily occur together [31] cumulative effects may occur when people engage in both behaviours. Thus, to assess this, we also tested whether engaging in multiple prosocial behaviours would be associated with pain interference. We further hypothesized that people who engage in both donating and volunteering would report lower pain interference than those who engage in neither, donating only, or volunteering only.

These hypotheses are motivated by Self-Determination Theory [32]. This theory of human motivation proposes three psychological experiences that increase people's motivation and well-being: autonomy, competence, and relatedness. These experiences also play a key role in prosocial behaviour [see 33 for a comprehensive review]. For instance, prior research shows people who were randomly allocated to a condition where they could decide how much money to give another participant reported greater well-being [34]. By engaging in prosocial behaviour, people may increase their sense of competence through feeling they are having a positive impact on others. While prior work has not evaluated effects of prosocial behaviour on sense of competence per se, studies show people report greater wellbeing when donating money to a high vs low impact charity [35]; having higher impact may support feelings of competence. Finally, prior research shows engaging in prosocial behaviour tends to increase social connection, which is itself a key predictor of mental and physical wellbeing [36].

Across all tests of our hypotheses we controlled for time and a range of potential confounders based on findings from prior literature [9,24].

1. Method

1.1. Sample

The sample was drawn from 54,569 individuals ages 15–102 participating at baseline in the United Kingdom Household Longitudinal Survey (UKHLS). UKHLS, administered to participants annually face-to-face, was designed to be representative of the UK population as respondents represent all regions of the UK, ages, as well as educational and socioeconomic sectors. The survey obtains information on demographic and socioeconomic characteristics as well as respondents' health, wellbeing, and lifestyle. Participants received information about the survey in advance and gave oral consent before starting the interview. The study has been further described elsewhere [37].

While ten waves (2010−2020) of data are available, the current study used nine waves (2 to 10) because the prosocial behaviour measures were unavailable in wave 1. For each independent variable, we included all respondents with appropriate data in the relevant analytic sample. Final sample-sizes ranged from 48,701–4868 respondents depending on which analytic sample was used. We excluded respondents with no pain data in any wave and with no covariate data at baseline (see below for more details).

1.2. Measures

Prosocial behaviour. Prosocial behaviours were self-reported at Wave 2. Following prior literature, we considered two forms of prosocial behaviour: donating money to charity and volunteering time to an organisation. We characterized behaviours in several ways as follows: (i) *Donating money to charity:* Respondents were asked (yes/no) 'In the last 12 months, have you donated any money to charities or other organisations?'. (ii) *Amount donated:* Respondents who reported donating were asked to report in British pounds 'Approximately how much money in total have you given to charities or other organisations in the last 12 months?' We divided the number reported by 100 to ease interpretation of the coefficients in the regression models. (iii) *Volunteering time to an organisation:* Respondents were asked (yes/no) 'In the last 12 months, have you given any unpaid help or worked as a volunteer for any type of local, national or international organisation or charity?' (iv) *Hours volunteered:* Respondents who reported volunteering were asked 'In the last 4 weeks approximately how many hours have you spent doing unpaid or voluntary work for any organisation?' To prevent duplicating findings from analyses considering associations with volunteering or not, analyses considering *hours volunteered* were conducted only among those who reported any volunteering in the last 4 weeks (i.e., respondents who reported having volunteered zero hours were excluded) and, following previous research, created a categorical variable among remaining respondents: 1–49 hours (reference category), 50–99 hours, and >100 hours [see 38].We also constructed a measure of combined prosocial behaviour with the following categories: (i) Neither (no donating and no volunteering), (ii) volunteering without donating, (iii) donating without volunteering, and (iv) both (donating and volunteering).

Pain interference. Pain is a biopsychosocial phenomenon and pain perception is determined by a complex mix of cognitive, emotional, and behavioural processes. While no single item can adequately characterize the experience, careful research has identified psychometrically valid assessment items and measures. Studies have measured chronic pain specifically [e.g., querying about pain in the past four weeks lasting >3 months;39] or general bodily pain levels [e.g., how much bodily pain past 4 weeks;[40] often combined with a measure asking about the extent to which pain interfered with ability to work [generally queried in the last four weeks;10]. Due to data availability (only one item was queried), we use a single-item measure that captures how much pain interferes with work (including both work outside the home and housework) using a similar time frame of past 4 weeks. However, other work has shown that even single items asking about pain interference

correspond well with other measures of bodily or chronic pain [41].

Pain interference was assessed at each wave (2−10) according to whether a respondent was experiencing physical pain that interfered with their ability to work. Specifically, respondents were asked 'During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?' and response options ranged from 'Not at all' (1) to 'Extremely' (5). Prior research has documented the validity and reliability of numeric pain scales [42,43]. We considered pain interference as a continuous variable in all models. We excluded 8962 (11.6%) respondents without pain interference data in any wave. Of note, 12,720 (16.47%) respondents had pain interference data in only one wave.

Covariates. Demographics were self-reported at baseline: age (years), gender (men, women), race (British/Irish/other white, mixed ethnicity, Indian/Pakistani/ Bangladeshi, Chinese/Other Asians, Black Caribbean/Africans, other ethnic group), marital status (single, married/civil partner, separated/divorced, widowed), employment status (paid employment(full-time/part-time), self-employed, unemployed, out of labour force), level of education (less than high-school (leave at 16), A level/some college, university/college degree, other education), personal income (British pounds, used as a continuous variable), health status (single item querying long-standing illness presence/absence), and level of depression (single item: querying feeling unhappy or depressed, not at all (1) to much more than usual (4)). We excluded those with missing covariates, which was generally minimal except education and depression status. Among respondents with donating data at baseline, covariates with more missing data included education (9666; 19%) and depression (4867; 10%).

1.3. Statistical analysis

We first examined descriptive statistics and evaluated the distribution of covariates across levels of donating (yes/no) and volunteering (yes/no). We also examined the correlation between donating and volunteering. To test our primary hypotheses that higher levels of prosocial behaviour would be associated with lower pain, we conducted linear mixed models. We used random intercepts to account for individual variation in pain. In all models, we used prosocial behaviour at baseline as the independent variable and repeated measures of pain across the nine waves as the dependent variable. We further controlled for demographic and other characteristics that may confound the link between pain and prosocial behaviour.

Four regression models were built sequentially. The first model contained baseline prosocial behaviour and a linear term for time in 2-year intervals. The second model adjusted for age, gender, and race. The third model added other demographics including marital status, employment status, level of education, and log of personal income. The final fully adjusted model added covariates regarding presence of a long-standing illness and level of depression. In all models we examined whether rate of change in pain over time varied depending on baseline prosocial behaviour. If no associations with rate of change in pain interference were evident, we describe findings from models without an interaction term between the prosocial behaviour and time and thereby characterize associations of the prosocial behaviour with pain interference averaged across all time points. To account for the likelihood that individuals experiencing higher pain interference might be more likely to drop out of the study, all models included weights based on the inverse probability of not having reported pain interference in follow-up waves [44].

We conducted several additional sensitivity analyses. First, we considered if gender moderated associations by testing an interaction term in all models. Second, we conducted analyses after removing respondents with pain data at only one of the nine waves. Third, because fully adjusted analyses included only respondents with data on education and depression ($N = 35{,}000$ approx.), but more minimally adjusted models included all eligible participants ($N = 48{,}700$ approx.), we evaluated differences on other covariates between respondents with and without depression and education data (see Table S.1 in the Supplementary Materials). We also conducted models with imputed education data (our covariate with the largest number of missing values). These data were created by conducting polytomous logistic regression models which generated a value for education based on a rich set of variables including baseline health status, age, gender, race, marital status, employment status, income, donated (yes/no), volunteered (yes/no), and baseline pain interference. Fourth, we conducted models accounting for clustering by household because our sample contained some individuals from the same household (ranging between 4,160 and 22,048 households, depending on analytic sample). Fifth, we conducted analyses considering associations of prosocial behaviours with pain interference over time, first removing the baseline pain assessment to ensure the prosocial behaviour occurred prior to the report of pain, and then using updated prosocial behaviour as reported at each wave together with random intercepts accounting for individual differences over time (pain and prosocial behaviour were both assessed at waves 2, 4, 6, 8, and 10; data on prosocial behaviours were available only from even waves). Finally, we obtained *E*-values [45] to examine the extent to which our main relationships that reached statistical significance were subject to unmeasured confounding at a level that might render these relationships less meaningful. All analyses were conducted using the R studio statistical software version 2022.07.1–554 and statistical significance was set at $p < 0.05$, two-tailed.

2. Results

Characteristics of the sample by donating and volunteering status are shown in Table 1. Among 35,000 respondents, mean age ranged from 43 to 48 years across prosocial behaviour status and about 45% of the sample were men. Most respondents were British, Irish or from another white background. About half were married and in paid employment. Regarding levels of prosocial behaviours, 68% of people donated money to charity, 19% volunteered time to an organisation at baseline, and 16% engaged in both of these prosocial behaviours. The correlation between donating money to charity and volunteering time to an organisation was modest, $r = 0.18$ ($p < 0.001$). In models with all covariates, there was a modest negative association of time with pain. Respondents without versus with education data were somewhat older and in poorer health, while respondents without versus with depression data were younger and reported higher pain. See Table S.1 for details.

We found evidence that rate of change in pain was associated with donating activity and amount donated. Overall, respondents who did versus did not donate money to charity reported a slower rise in pain over time (Table 2). This association was maintained in the fully adjusted regression controlling for wave, demographic characteristics, long-standing illness, and depression ($b_{donating*wave} = -0.004$, $p = 0.009$, 95%CI [−0.007, −0.001]). The negative association between donating and pain held when averaging effects across all time points ($b_{donating} = -0.059$, $p < 0.001$, 95%CI [−0.077, −0.041]; Table 5). Moreover, individuals who donated more versus less money to charity reported lower pain averaged across all time points (e.g., fully adjusted regression $b_{amount\ donated} = -0.002$, $p = 0.022$, 95%CI [−0.004, −0.001]; Table 5), but evidence that this behaviour was associated with change in rate of pain interference over time was weaker (Table 2). Tables S.2 to S.5 show coefficients for all covariates.

We did not find evidence that volunteering time was associated with rate of change in pain interference over time (Table 3). Across all models, individuals who did versus did not volunteer time reported lower pain interference averaged across all time points (e.g., fully adjusted regression $b_{volunteering} = -0.086$, $p < 0.001$, 95%CI [−0.107, −0.066]; Table 5). Number of hours volunteered was not associated with pain interference in any model. For covariate coefficients see Tables S.6 to S.9.

Associations of engaging in both, one, and neither of these

Table 1
Distribution of covariates by donation (N. of individuals = 35,000) or volunteer status (N. of individuals = 35,017) at baseline.

	Donating		Volunteering	
	Yes	No	Yes	No
	(*N* = 23,819; 68.1%)	(*N* = 11,181; 31.9%)	(*N* = 6672; 19.1%)	(*N* = 28,345; 80.9%)
Age (years)	48.79 (17.58)	42.23 (18.48)	47.59 (18.28)	46.49 (18.09)
Male	9973 (41.86)	5378 (48.09)	2742 (41.09)	12,620 (44.52)
Race				
British/Irish/Other white *(reference category)*	20,960 (88)	9021 (80.68)	5867 (87.94)	24,126 (85.15)
Mixed ethnicity	328 (1.37)	223 (1.99)	108 (1.62)	443 (1.54)
Indian/Pakistani/ Bangladeshi	1394 (5.85)	903 (8.08)	322 (4.83)	1978 (6.96)
Chinese/Other Asians	321 (1.35)	256 (2.29)	97 (1.45)	481 (1.69)
Black Caribbean/Africans	693 (2.91)	660 (5.90)	240 (3.59)	1114 (3.93)
Other ethnic group	123 (0.52)	118 (1.06)	38 (0.57)	203 (0.72)
Marital status				
Single (reference category)	6083 (25.54)	4641 (41.51)	1943 (29.11)	8783 (31)
Married/Civil partner	13,553 (56.90)	4717 (42.19)	3723 (55.80)	14,559 (51.36)
Separated/ Divorced	2629 (11.04)	1308 (11.70)	618 (9.27)	3320 (11.71)
Widowed	1554 (6.52)	515 (4.60)	388 (5.82)	1683 (5.93)
Employment status				
Paid employment(ft/pt) *(reference category)*	12,107 (50.83)	4501 (40.26)	2895 (43.40)	13,719 (48.41)
Self employed	1804 (7.57)	633 (5.66)	604 (9.05)	1834 (6.47)
Unemployed	755 (3.17)	1295 (11.58)	271 (4.06)	1780 (6.28)
Out of labour force	9153 (38.43)	4752 (42.50)	2902 (43.49)	11,012 (38.84)
Level of education				
< high-school (leave at 16) *(ref category)*	6773 (28.44)	3775 (33.77)	1631 (24.45)	8923 (31.48)
A level/some college	4208 (17.67)	1848 (16.52)	1394 (20.89)	4663 (16.45)
University/college degree	7241 (30.40)	1780 (15.92)	2611 (39.13)	6415 (22.63)
Other education	5597 (23.49)	3778 (33.79)	1036 (15.53)	8344 (29.44)
Personal income	20,770.63 (18,941.41)	13,931.35 (12,687.31)	20,599.27 (20,453.89)	18,107.76 (16,674.02)
Long-standing illness - Yes	8490 (35.64)	3610 (32.28)	2373 (35.56)	9733 (34.34)
Depression (range = 1–4)	1.81 (0.8)	1.91 (0.87)	1.79 (0.8)	1.85 (0.82)

Note: Categorical variables show N(%). Continuous variables (i.e., age, personal income, and depression) show mean (standard deviation). Additional descriptive statistics can be found in Tables S.18 in the SM.

Table 2
Linear mixed models showing association between donating money to charity and change in pain interference over 10 years. Values are b [95% confidence interval].

	Dependent variable: Pain interference			
	Unadjusted[1]	Minimally adjusted[2]	Adjusted for all demographics[3]	Fully adjusted[4]
Donated - *Yes*	−0.068*** [−0.088, −0.048]	−0.176*** [−0.196, −0.157]	−0.047*** [−0.069, −0.025]	−0.044*** [−0.066, −0.023]
Wave	0.014*** [0.012, 0.016]	0.014*** [0.012, 0.016]	0.016*** [0.013, 0.018]	0.015*** [0.013, 0.018]
Donated – *Yes* x Wave	−0.004** [−0.006, −0.001]	−0.003* [−0.006, −0.001]	−0.004** [−0.007, −0.001]	−0.004** [−0.007, −0.001]
Amount donated	−0.007*** [−0.009, −0.004]	−0.011*** [−0.013, −0.008]	−0.001 [−0.004, 0.001]	−0.001 [−0.004, 0.001]
Wave	0.012*** [0.010, 0.013]	0.012*** [0.010, 0.013]	0.013*** [0.011, 0.014]	0.013*** [0.011, 0.014]
Amount donated x Wave	−0.001* [−0.001, −0.000]	−0.001 [−0.001, 0.000]	−0.001 [−0.001, 0.000]	−0.001 [−0.001, 0.000]

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Pain interference is a continuous variable (1–5). For models assessing donated N's varied from 48,701- 34,955; for models assessing amount donated N's varied from 30,697- 22,450. See SM for full models and more details.
Column 1 shows the main independent variable included in each model. Each independent variable was entered separately in each regression model. Donated, Amount donated, and all covariates are obtained at Wave 2 unless otherwise indicated.
[1] Includes the main independent variable and wave.
[2] Model 1 covariates + age, gender, and race.
[3] Model 2 covariates + marital status, employment status, level of education, and log of personal income.
[4] Model 3 covariates + long-term illness and depression.

behaviours in relation to rate of change in pain interference over time were evident only when individuals were donating (Table 4), reflecting the findings reported above. Thus, here we report associations that reflect *average* effects of various combinations of these behaviours on pain across multiple time points rather than effects on *changes* in pain over time. Engaging in both prosocial behaviours was associated with lower pain interference in a graded manner (see Table 5). Across all models, individuals who engaged in either volunteering or donating, or both reported lower pain across time than those who were not engaged in either prosocial behaviour. Associations with engaging in two versus only one behaviour appear stronger (see Fig. 1). However, only some of the differences in estimates of associations with pain interference were statistically significant (χ^2 test): volunteering without donating ($b = -0.107$, $p < 0.001$, 95% CI[−0.152, −0.062]) versus donating without volunteering ($b = -0.055$, $p < 0.001$, 95% CI[−0.075, −0.036]); donating without volunteering versus volunteering and donating ($b = -0.129$, $p < 0.001$, 95% CI[−0.155, −0.103]). The difference in associations for volunteering without donating versus for volunteering and donating was not statistically significant. Benefits for pain interference appear similar if individuals engaged in volunteering only or engaged in both prosocial behaviours. Models showing coefficients for all the covariates can be found in Tables S.10 and S.11.

We conducted additional sensitivity analyses. First, we found no evidence gender moderated these associations. Second, after removing the 12,720 respondents with only one pain measure, results were similar to our main analysis (Tables S.12). Third, because fully adjusted analyses included only respondents who also had data on education and depression ($N = 48,700$ approx.), but more minimally adjusted models

Table 3
Linear mixed models showing association between volunteering time to an organisation and change in pain interference over 10 years. Values are b [95% confidence interval].

	Dependent variable: Pain interference			
	Unadjusted[1]	Minimally adjusted[2]	Adjusted for all demographics[3]	Fully adjusted[4]
Volunteered - *Yes*	−0.136*** [−0.161, −0.112]	−0.152*** [−0.175, −0.128]	−0.078*** [−0.103, −0.052]	−0.083*** [−0.107, −0.059]
Wave	0.012*** [0.011, 0.013]	0.012*** [0.010, 0.013]	0.013*** [0.012, 0.015]	0.013*** [0.011, 0.014]
Volunteered – *Yes* x Wave	−0.001 [−0.003, 0.003]	−0.001 [−0.004, 0.002]	−0.001 [−0.004, 0.002]	−0.001 [−0.004, 0.002]
Hours volunteered *(Ref.: 1 to 49 hours)*				
50 to 99 h	0.009 [−0.110, 0.127]	0.004 [−0.113, 0.121]	−0.062 [−0.188, 0.064]	−0.063 [−0.186, 0.059]
Over 100 h	0.183 [−0.006, 0.372]	0.193* [0.008, 0.378]	0.153 [−0.052, 0.358]	0.084 [−0.116, 0.283]
Wave	0.012*** [0.009, 0.015]	0.012*** [0.009, 0.015]	0.013*** [0.010, 0.016]	0.013*** [0.010, 0.016]
Hours volunteered (*Ref:* 1–49 *hours*) X Wave				
50 to 99 h x Wave	0.002 [−0.014, 0.017]	0.002 [−0.014, 0.017]	0.004 [−0.012, 0.021]	0.003 [−0.014, 0.020]
Over 100 h hrs x Wave	−0.008 [−0.031, 0.014]	−0.009 [−0.032, 0.014]	−0.009 [−0.035, 0.017]	−0.013 [−0.039, 0.014]

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Pain interference is a continuous variable (1–5). For models assessing volunteered N's varied from 48,728- 34,972; for models assessing hours volunteered N's varied from 6558 to 4868. See SM for full models and more details.
Column 1 shows the main independent variable included in each model. Each independent variable was entered separately in each regression model. Volunteered, hours volunteered, and all covariates are obtained at Wave 2 unless otherwise indicated.
[1] Includes the main independent variable and wave.
[2] Model 1 covariates + age, gender, and race.
[3] Model 2 covariates + marital status, employment status, level of education, and log of personal income.
[4] Model 3 covariates + long-term illness and depression.

included all eligible participants (N = 35,000 approx.), we evaluated differences on other covariates between respondents with and without depression and education data (see Table S.1 in the Supplementary Materials). Models with imputed education data yielded the same results (Tables S.13 and S.14). In models accounting for clustering by household, results were virtually identical to those described above. In analyses after removing the assessment of pain at baseline, results remained unchanged (Table S.15). In analyses using repeated measures of pain interference and time updated measures of prosocial behaviour, results were largely unchanged. See Table S.16 for model estimates with each independent variable. We obtained the following *E*-values, whereby higher E-values signify greater magnitude of confounding is needed to render our associations less meaningful: E-value$_{\text{Donated Yes/No}}$ = 1.27 (95%CI = 1.22); E-value$_{\text{Amount Donated}}$ = 1.04 (95%CI = 1.01); E-value$_{\text{Volunteered Yes/No}}$ = 1.35 (95%CI = 1.3). For both donating and volunteering behaviours, in conjunction with adjustment for a broad set of other covariates, these moderate E-values suggest the effect of unmeasured confounding on the link between prosocial behaviour and pain interference is likely to be modest.

3. Discussion

This study explored links between prosocial behaviours and pain using nationally representative data from the UKHLS. We evaluated two behaviours; the modest correlation between them suggests they may be considered two different forms of prosociality. Moreover, while they may be characterized by similar features [e.g., helping others; see 33] whether an individual engages in one does not necessarily mean that they will engage in the other [31]. Averaged across all time points, people who did versus did not donate money to charity and volunteer time to an organisation reported lower pain. These findings are congruent with Self-Determination Theory [32] which suggests people gain wellbeing through three psychological factors integrally invoked when engaging in prosocial behaviour: competence (e.g., having impact by helping others), autonomy (e.g., choosing the amount of money donated and the time volunteered), and relatedness (e.g., creating social connection). Thus, through increasing psychological wellbeing, prosocial behaviour may activate pathways that reduce likelihood of experiencing pain, as described in more detail below. Our findings that people who donated more versus less money reported lower pain hint at a monotonic association. In contrast, we found no evidence that number of volunteering hours were linked to pain interference. Evidence in this domain suggests effects may occur once a certain threshold is reached or perhaps regardless of number of hours spent volunteering. Thus, while greater psychological wellbeing may be achieved when more (either material goods or time) is given, direct tests of this possibility are needed.

We also explored associations of prosocial behaviour with rate of change in pain interference over time. Donating, but not volunteering, was linked to a slower rise in pain over time. Of note, in our sample 68% of people donated money whereas 19% of people volunteered time; if effects on pain are somewhat modest, then detecting effects may be more difficult in a smaller sample of people who volunteered. Finally, we examined different combinations of prosocial behaviour and found relative to engaging in neither prosocial behaviour, engaging in donating or volunteering or both, were associated with less pain. However, engaging in both donating and volunteering did not differ significantly from engaging in volunteering only, suggesting volunteering may be the more potent factor. Social Network Theory, which suggests social integration is a key predictor of well-being, and also that volunteering activities increase integration because they involve contact with other people, may help explain these findings. In contrast, donating, which can be done without significant interpersonal interactions, may not affect levels of integration [46].

To put our associations in context, we note the estimate of volunteering time versus not was −0.083 whereas the estimate for one additional year of age was 0.006 (see Table S.6). Thus, pain interference associated with volunteering time was >10 times lower than that associated with each 1-year increase in age. Our findings are consistent with previous work showing prosocial behaviour, especially volunteering, is beneficial for both mental and physical health. When exploring physical health outcomes, most studies characterized prosociality via volunteering and helping informally. Our study is novel in two ways. First, we examine the roles of volunteering and donating separately, and the combination of these behaviours. Second, we focus on pain, a highly prevalent and costly health condition [47] vs other physical health outcomes like cardiovascular disease. Generally, our findings were robust even after accounting for initial health status and for depression, and other potential confounders. Taken together these findings suggest prosociality may provide a novel behavioural strategy for reducing likelihood of experiencing or developing pain interference over time. Moreover, these findings suggest that, while different prosocial behaviours may vary in potency of effects on pain, effects may be due to underlying elements common across the behaviours, including kindness,

Table 4
Linear mixed models showing association between combined prosocial behaviour and change in pain interference over 10 years. Values are b [95% confidence interval].

	Dependent variable: Pain interference			
	Unadjusted[1]	Minimally adjusted[2]	Adjusted for all demographics[3]	Fully adjusted[4]
Combination of donating and volunteering *(Ref.: Neither)*				
Volunteering without donating	−0.165*** [−0.219, −0.111]	−0.101*** [−0.153, −0.049]	−0.074* [−0.131, −0.018]	−0.086** [−0.140, −0.033]
Donating without volunteering	−0.059*** [−0.081, −0.037]	−0.158*** [−0.179, −0.137]	−0.040** [−0.064, −0.017]	−0.038** [−0.061, −0.015]
Volunteering and donating	−0.175*** [−0.205, −0.146]	−0.287*** [−0.316, −0.259]	−0.112*** [−0.144, −0.080]	−0.114*** [−0.145, −0.084]
Wave	0.015*** [0.013, 0.017]	0.015*** [0.012, 0.017]	0.016*** [0.014, 0.019]	0.016*** [0.014, 0.019]
Combination of donating and volunteering (*Ref.: Neither*) x Wave				
Volunteering without donating x Wave	−0.005 [−0.011, 0.002]	−0.006 [−0.012, 0.001]	−0.006 [−0.013, 0.002]	−0.006 [−0.013, 0.002]
Donating without volunteering x Wave	−0.004** [−0.007, −0.002]	−0.004** [−0.007, −0.001]	−0.005** [−0.008, −0.002]	−0.005** [−0.008, −0.002]
Volunteering and donating x Wave	−0.003 [−0.006, 0.001]	−0.003 [−0.007, 0.000]	−0.004* [−0.008, −0.000]	−0.004 [−0.008, 0.000]

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Pain interference is a continuous variable (1–5). For models assessing combination of donating and volunteering N's varied from 48,698–34,953 on missing covariates. See SM for full models and more details.
Column 1 shows the independent variable included in each model. Combination of donating and volunteering and all covariates are obtained at Wave 2 unless otherwise indicated. The combined variable of prosocial behaviour has 4 categories in which 'neither volunteering nor donating' is the reference category. Estimates associated with the other combinations are compared with engaging in neither prosocial behaviour. Rows show estimates for each combination possible, and columns show estimates for increasingly adjusted models for that particular combination.
[1] Includes the main independent variable and wave.
[2] Model 1 covariates + age, gender, and race.
[3] Model 2 covariates + marital status, employment status, level of education, and log of personal income.
[4] Model 3 covariates + long-term illness and depression.

Table 5
Linear mixed models showing associations between donating money to charity, volunteered time to an organisation, and pain interference over 10 years. Models show the average pooled effects of each prosocial behaviour on pain over time. Values are b [95% confidence interval].

	Dependent variable: Pain interference			
	Unadjusted[1]	Minimally adjusted[2]	Adjusted for all demographics[3]	Fully adjusted[4]
Donated - *Yes*	−0.081*** [−0.099, −0.063]	−0.189*** [−0.206, −0.172]	−0.062*** [−0.082, −0.043]	−0.059*** [−0.077, −0.041]
Wave	0.012*** [0.011, 0.013]	0.012*** [0.010, 0.013]	0.013*** [0.011, 0.014]	0.013*** [0.011, 0.014]
Amount donated	−0.008*** [−0.010, −0.006]	−0.012*** [−0.014, −0.010]	−0.003* [−0.005, −0.001]	−0.002* [−0.004, −0.000]
Wave	0.011*** [0.010, 0.013]	0.011*** [0.010, 0.013]	0.012*** [0.010, 0.014]	0.012*** [0.010, 0.014]
Volunteered - *Yes*	−0.137*** [−0.158, −0.116]	−0.154*** [−0.175, −0.134]	−0.082*** [−0.104, −0.060]	−0.086*** [−0.107, −0.066]
Wave	0.012*** [0.011, 0.013]	0.012*** [0.010, 0.013]	0.013*** [0.012, 0.014]	0.013*** [0.011, 0.014]
Hours volunteered *(Ref.: 1 to 49 hours)*				
50 to 99 hs	0.015 [−0.085, 0.115]	0.011 [−0.087, 0.108]	−0.044 [−0.149, 0.061]	−0.050 [−0.148, 0.049]
Over 100 hs	0.145 [−0.013, 0.304]	0.153 [−0.001, 0.307]	0.112 [−0.059, 0.283]	0.028 [−0.134, 0.190]
Wave	0.012*** [0.009, 0.015]	0.012*** [0.009, 0.015]	0.013*** [0.010, 0.016]	0.013*** [0.010, 0.016]
Combination of donating and volunteering *(Ref.: Neither)*				
Volunteering without donating	−0.183*** [−0.230, −0.135]	−0.123*** [−0.168, −0.078]	−0.095*** [−0.144, −0.047]	−0.107*** [−0.152, −0.062]
Donating without volunteering	−0.075*** [−0.094, −0.056]	−0.173*** [−0.192, −0.155]	−0.058*** [−0.079, −0.037]	−0.055*** [−0.075, −0.036]
Volunteering and donating	−0.186*** [−0.212, −0.160]	−0.299*** [−0.324, −0.274]	−0.128*** [−0.156, −0.100]	−0.129*** [−0.155, −0.103]
Wave	0.012*** [0.011, 0.013]	0.012*** [0.011, 0.013]	0.013*** [0.012, 0.014]	0.013*** [0.011, 0.014]

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Pain interference is a continuous variable (1–5). For models assessing donated N's varied from 48,701- 34,955; for models assessing amount donated N's varied from 30,697-22,450; for models assessing Volunteered N's varied from 48,728- 34,972; for models assessing hours volunteered N's varied from 6558 to 4868; for models assessing combination of donating and volunteering N's varied from 48,698–34,953 on missing covariates. See SM for full models and more details.
Column 1 shows the main independent variable included in each model. Each independent variable was entered separately in each regression model. All covariates are obtained at Wave 2 unless otherwise indicated.
[1] Includes the main independent variable and wave.
[2] Model 1 covariates + age, gender, and race.
[3] Model 2 covariates + marital status, employment status, level of education, and log of personal income.
[4] Model 3 covariates + long-term illness and depression.

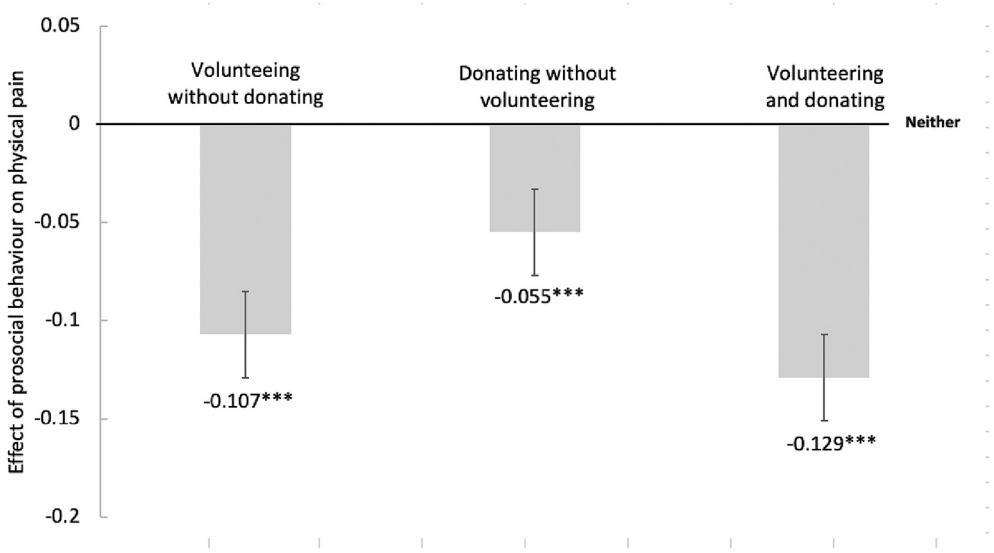

Fig. 1. Effect of prosocial behaviours combined on physical pain averaged across 10 years of follow-up. This figure shows the unstandardized coefficients of combination of donating and volunteering from linear mixed models. Estimates from these models can be found at the bottom of the Fully adjusted column in Table 5.

compassion, or helping toward others, rather than to any specific behaviour per se.

What mechanisms underlie the observed associations between prosocial behaviour and pain interference? Prior research shows social connections and social support protect physical health [48]. For example, in a study with 6500 older adults, Steptoe et al. [49] found social isolation and loneliness were linked to greater mortality risk, and noted effects of being socially isolated were particularly potent. Also, engaging in volunteering may lead to greater adoption of healthy behaviours like physical activity [50]. Links between donating or volunteering and mental health may also help explain findings from the current study. Prior research has found prosocial behaviour promotes better mental health (Dunn, Aknin, and Norton 2008; Kim et al. 2020) and that physical pain and mental health are highly interrelated [51]. Benefits that prosocial behaviour confer on mental health may translate into lower pain interference.

This study has some limitations. First, we cannot fully rule out concerns about reverse causality whereby individuals experiencing more pain may not engage in prosocial behaviours, due in part to reduced mental and physical capacity. However, the longitudinal study design, the ability to control for baseline health status and depression, and findings that prosocial behaviours are also associated prospectively with rate of change in pain interference over time mitigate these concerns. Second, we could not control for respondents' health behaviours as measures at the right time points were unavailable. Third, although we used a longitudinal design and controlled for numerous covariates, unmeasured confounding remains possible. Finally, researchers seeking to collect their own data should consider using the same time frame across questions.

Taken together, our findings are consistent with the possibility that prosocial behaviours causally contribute to reduced experiences of pain interference over time even after controlling for relevant factors such as income and employment. This study contributes to the body of work that explores whether prosocial behaviour is beneficial for people's health and quality of life more generally, suggesting that prosociality may have systemic effects related to health, rather than applying to only a single system or outcome. These findings are relevant to researchers across the social sciences, physicians, and policymakers and suggest prosocial behaviours may provide a novel target for strategies to enhance population health, given prior work demonstrating these behaviours are modifiable through systematic interventions [52]. Identifying and understanding the factors that may help to alleviate pain is key to the design of public policies that aim to increase citizens' wellbeing and reduce the strain in the healthcare system.

Data availability

Data and script for analyses are available through Open Science Framework https://osf.io/wjr34/?view_only=e9efc8b203794998b8cdb7546c1c3a43

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychores.2023.111325.

References

[1] A.J. Weiss, H.J. Jiang, Most Frequent Reasons for Emergency Department Visits, 2018 277, Agency for Healthcare Research and Quality, 2018, pp. 1–15.
[2] National Health Service, Best practice solutions - Musculoskeletal. https://www.england.nhs.uk/elective-care-transformation/best-practice- solutions/musculoskeletal/, 2022.
[3] D.A. Glei, A. Stokes, M. Weinstein, Changes in mental health, pain, and drug misuse since the mid-1990s: is there a link? Soc. Sci. Med. 246 (2020), 112789 https://doi.org/10.1016/j.socscimed.2020.112789.
[4] H. Breivik, E. Eisenberg, T. O'Brien, The individual and societal burden of chronic pain in Europe: the case for strategic prioritisation and action to improve knowledge and availability of appropriate care, BMC Public Health 13 (2013) 1–14, https://doi.org/10.1186/1471-2458-13-1229.
[5] M. Dueñas, B. Ojeda, A. Salazar, J.A. Mico, I. Failde, A review of chronic pain impact on patients, their social environment and the health care system, J. Pain Res. 9 (2016) 457–467, https://doi.org/10.2147/JPR.S105892.
[6] K. Wiech, I. Tracey, The influence of negative emotions on pain: behavioral effects and neural mechanisms, NeuroImage. 47 (2009) 987–994, https://doi.org/10.1016/j.neuroimage.2009.05.059.
[7] M.R. Frumkin, T.L. Rodebaugh, The role of affect in chronic pain: a systematic review of within-person symptom dynamics, J. Psychosom. Res. 147 (2021), 110527, https://doi.org/10.1016/j.jpsychores.2021.110527.
[8] E.Y. Chou, B.L. Parmar, A.D. Galinsky, Economic insecurity increases physical pain, Psychol. Sci. 27 (2016) 443–454, https://doi.org/10.1177/0956797615625640.
[9] L. Macchia, A.J. Oswald, Physical pain, gender, and the state of the economy in 146 nations, Soc. Sci. Med. 287 (2021), 114332, https://doi.org/10.1016/j.socscimed.2021.114332.
[10] L.R. Wilkinson, M.H. Schafer, R. Wilkinson, How painful is a recession? An assessment of two future-oriented buffering mechanisms, Soc. Sci. Med. 255 (2020), 112455, https://doi.org/10.1016/j.socscimed.2019.112455.
[11] L.M. Jaremka, R.R. Andridge, C.P. Fagundes, C.M. Alfano, S.P. Povoski, A. M. Lipari, D.M. Agnese, M.W. Arnold, W.B. Farrar, L.D. Yee, W.E. Carson, T. Bekaii-Saab, E.W. Martin, C.R. Schmidt, J.K. Kiecolt-Glaser, Pain, depression, and fatigue: loneliness as a longitudinal risk factor, Health Psychol. 33 (2014) 948–957, https://doi.org/10.1037/a0034012.

[12] A. Loeffler, A. Steptoe, Bidirectional longitudinal associations between loneliness and pain, and the role of inflammation, Pain. 162 (2021) 930–937, https://doi.org/10.1097/j.pain.0000000000002082.
[13] T.T. Brown, J. Partanen, L. Chuong, V. Villaverde, A. Chantal Griffin, A. Mendelson, Discrimination hurts: the effect of discrimination on the development of chronic pain, Soc. Sci. Med. 204 (2018) 1–8, https://doi.org/10.1016/j.socscimed.2018.03.015.
[14] N. Eisenberg, T.L. Spinrad, A. Knafo-Noam, Prosocial development, in: M. Lamb, R. M. Lerner (Eds.), Handbook of Child Psychology and Developmental Science: Socioemotional Processes, Wiley, New York, NY, 2015, pp. 610–656.
[15] B.P.H. Hui, J.C.K. Ng, E. Berzaghi, L.A. Cunningham-Amos, A. Kogan, Rewards of kindness? A meta-analysis of the link between prosociality and well-being, Psychol. Bull. 146 (2020) 1084–1116, https://doi.org/10.1037/bul0000298.
[16] D.A. Schroeder, W.G. Graziano, J.A. Piliavin, E. Siegl, Health and well-being consequences of formal volunteering, 2014, https://doi.org/10.1093/oxfordhb/9780195399813.013.024.
[17] E.W. Dunn, L.B. Aknin, M.I. Norton, Spending money on others promotes happiness, Science. 31 (2008) 1687–1688, https://doi.org/10.1126/science.1150952.
[18] L.B. Aknin, A.V. Whillans, M.I. Norton, E.W. Dunn, Happiness and prosocial behavior: an evaluation of the evidence, World Happiness Report 2019 (2019).
[19] W.T. Harbaugh, U. Mayr, D.R. Burghart, Neural responses to taxation and voluntary giving reveal motives for charitable donations, Science. 316 (2007) 1622–1625, https://doi.org/10.1126/science.1140738.
[20] A.V. Whillans, E.W. Dunn, G.M. Sandstrom, S.S. Dickerson, K.M. Madden, Is spending money on others good for your h heart ? Health Psychol. 35 (2016) 574–583.
[21] H.W. Mak, R. Coulter, D. Fancourt, Relationships between volunteering, neighbourhood deprivation and mental wellbeing across four British birth cohorts: evidence from 10 years of the UK household longitudinal study, Int. J. Environ. Res. Public Health 19 (2022), https://doi.org/10.3390/ijerph19031531.
[22] J.A. Burr, J.E. Mutchler, S.H. Han, Volunteering and health in later life, in: Handbook of Aging and the Social Sciences., 2021, pp. 303–319, https://doi.org/10.1016/B978-0-12-815970-5.00019-X.
[23] S.I. Hong, N. Morrow-Howell, Health outcomes of Experience Corps®: a high-commitment volunteer program, Soc. Sci. Med. 71 (2010) 414–420, https://doi.org/10.1016/j.socscimed.2010.04.009.
[24] E.S. Kim, A.V. Whillans, M.T. Lee, Y. Chen, T.J. VanderWeele, Volunteering and subsequent health and well-being in older adults: an outcome-wide longitudinal approach, Am. J. Prev. Med. 59 (2020) 176–186, https://doi.org/10.1016/j.amepre.2020.03.004.
[25] J.A. Burr, S. Han, H.J. Lee, J.L. Tavares, J.E. Mutchler, Health benefits associated with three helping behaviors: evidence for incident cardiovascular disease, J. Gerontol. B Psychol. Sci. Soc. Sci. 73 (2018) 492–500, https://doi.org/10.1093/geronb/gbx082.
[26] H.M.C. Schreier, K.A. Schonert-Reichl, E. Chen, Effect of volunteering on risk factors for cardiovascular disease in adolescents, JAMA Pediatr. 167 (2013) 327–332, https://doi.org/10.1001/jamapediatrics.2013.1100.
[27] M.A. Musick, A.R. Herzog, J.S. House, Volunteering and mortality among older adults: findings from a national sample, J. Gerontol. B Psychol. Sci. Soc. Sci. 54 (1999) 173–180, https://doi.org/10.1093/geronb/54B.3.S173.
[28] S. Konrath, A. Fuhrel-Forbis, A. Lou, S. Brown, Motives for volunteering are associated with mortality risk in older adults, Health Psychol. 31 (2012) 87–96, https://doi.org/10.1037/a0025226.
[29] P. Arnstein, M. Vidal, C. Wells-Federman, B. Morgan, M. Caudill, From chronic pain patient to peer: benefits and risks of volunteering, Pain Manag. Nurs. 3 (2002) 94–103, https://doi.org/10.1053/jpmn.2002.126069.
[30] H. Qu, Differential Associations Between Volunteering and Subjective Well-Being by Labor Force Status: An Investigation of Experiential and Evaluative Well-Being Using Time Use Data, Springer, Netherlands, 2022, https://doi.org/10.1007/s10902-021-00471-5.
[31] A.L. Brown, J. Meer, J.F. Williams, Why do people volunteer? An experimental analysis of preferences for time donations, Manag. Sci. 65 (2019) 1455–1468, https://doi.org/10.1287/mnsc.2017.2951.
[32] R.M. Ryan, E.L. Deci, Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being, Am. Psychol. 55 (2000) 68–78.
[33] L.B. Aknin, A.V. Whillans, Helping and happiness: a review and guide for public policy, Soc. Issues Policy Rev. 15 (2021) 3–34, https://doi.org/10.1111/sipr.12069.
[34] N. Weinstein, R.M. Ryan, When helping helps: autonomous motivation for prosocial behavior and its influence on well-being for the helper and recipient, J. Pers. Soc. Psychol. 98 (2010) 222–244, https://doi.org/10.1037/a0016984.
[35] L.B. Aknin, E.W. Dunn, A.V. Whillans, A.M. Grant, M.I. Norton, Making a difference matters: impact unlocks the emotional benefits of prosocial spending, J. Econ. Behav. Organ. 88 (2013) 90–95, https://doi.org/10.1016/j.jebo.2013.01.008.
[36] L.B. Aknin, G.M. Sandstrom, E.W. Dunn, M.I. Norton, It's the recipient that counts: spending money on strong social ties leads to greater happiness than spending on weak social ties, PLoS One 6 (2011) 6–8, https://doi.org/10.1371/journal.pone.0017018.
[37] University of Essex, Institute for Social and Economic Research, Understanding Society: Waves 1–11, 2009–2020 and Harmonised BHPS: Waves 1–18, 1991–2009. [data collection], 15th Edition. UK Data Service. SN: 6614, 2022, https://doi.org/10.5255/UKDA-SN-6614-16.
[38] T.D. Windsor, K.J. Anstey, B. Rodgers, Volunteering and psychological well-being among young-old adults: how much is too much? Gerontologist. 48 (2008) 59–70, https://doi.org/10.1093/geront/48.1.59.
[39] D.G. Blanchflower, A. Bryson, Chronic pain: evidence from the national child development study, PLoS One 17 (2022), e0275095, https://doi.org/10.1371/journal.pone.0275095.
[40] A.L. Hassett, D. Whibley, A. Kratz, D.A. Williams, Measures for the assessment of pain in adults, Arthritis Care Res. 72 (2020) 342–357, https://doi.org/10.1002/acr.24222.
[41] K.F. Cook, B.D. Schalet, M.A. Kallen, J.P. Rutsohn, D. Cella, Establishing a common metric for self-reported pain: linking BPI Pain Interference and SF-36 Bodily Pain Subscale scores to the PROMIS Pain Interference metric, Qual. Life Res. 24 (2015) 2305–2318, https://doi.org/10.1007/s11136-015-0987-6.
[42] British Pain Society, The Outcome Measures. https://www.britishpainsociety.org/static/uploads/resources/files/Outcome_Measures_January_2019.pdf, 2018.
[43] A. Williamson, B. Hoggart, Pain: a review of three commonly used pain rating scales, J. Clin. Nurs. 14 (2005) 798–804, https://doi.org/10.1111/j.1365-2702.2005.01121.x.
[44] J.W. Hogan, T. Lancaster, Instrumental variables and inverse probability weighting for causal inference from longitudinal observational studies, Stat. Methods Med. Res. 13 (2004) 17–48, https://doi.org/10.1191/0962280204sm351ra.
[45] T.J. VanderWeele, P. Ding, Sensitivity analysis in observational research: introducing the E-value, Ann. Intern. Med. 167 (2017) 268–274, https://doi.org/10.7326/M16-2607.
[46] L.F. Berkman, T. Glass, I. Brissette, T.E. Seeman, From social integration to health: Durkheim in the new millennium, Soc. Sci. Med. 51 (2000) 843–857, https://doi.org/10.1016/S0277-9536(00)00065-4.
[47] D.J. Gaskin, P. Richard, The economic costs of pain in the United States, J. Pain 13 (2012) 715–724, https://doi.org/10.1016/j.jpain.2012.03.009.
[48] K.P. Smith, N.A. Christakis, Social networks and health, Annu. Rev. Sociol. 34 (2008) 405–429, https://doi.org/10.1146/annurev.soc.34.040507.134601.
[49] A. Steptoe, A. Shankar, P. Demakakos, J. Wardle, Social isolation, loneliness, and all-cause mortality in older men and women, Proc. Natl. Acad. Sci. U. S. A. 110 (2013) 5797–5801, https://doi.org/10.1073/pnas.1219686110.
[50] E.J. Tan, Q.L. Xue, T. Li, M.C. Carlson, L.P. Fried, Volunteering: a physical activity intervention for older adults - the experience Corps® program in Baltimore, J. Urban Health 83 (2006) 954–969, https://doi.org/10.1007/s11524-006-9060-7.
[51] C.G. Abdallah, P. Geha, Chronic pain and chronic stress: two sides of the same coin? Chronic Stress. 1 (2017) 1–10, https://doi.org/10.1177/2470547017704763.
[52] M.C. Carlson, K.I. Erickson, A.F. Kramer, M.W. Voss, N. Bolea, M. Mielke, S. McGill, G.W. Rebok, T. Seeman, L.P. Fried, Evidence for neurocognitive plasticity in at-risk older adults: the experience corps program, J. Gerontol. Ser. A Biol. Sci. Med. Sci. 64 (2009) 1275–1282, https://doi.org/10.1093/gerona/glp117.