Author(s): Stenroth, Sini M.; Pynnönen, Katja; Haapanen, Markus J.; Vuoskoski, Pirjo; Mikkola, Tuija M.; Eriksson, Johan G.; von Bonsdorff, Mikaela B.

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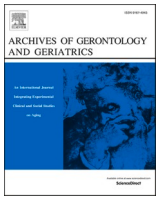

Association between resilience and frailty in older age: Findings from the Helsinki Birth Cohort Study

Sini M. Stenroth [a,b,*], Katja Pynnönen [a], Markus J. Haapanen [b,c,d], Pirjo Vuoskoski [e], Tuija M. Mikkola [b,f,g], Johan G. Eriksson [b,c,h,i], Mikaela B. von Bonsdorff [a,b]

[a] Gerontology Research Center and Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland
[b] Folkhälsan Research Center, Helsinki, Finland
[c] Department of General Practice and Primary Health Care, University of Helsinki and Helsinki University Hospital, Helsinki, Finland
[d] Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden
[e] Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland
[f] Clinicum, Faculty of Medicine, University of Helsinki, Helsinki, Finland
[g] Population Health Unit, Finnish Institute for Health and Welfare, Helsinki, Finland
[h] Yong Loo Lin School of Medicine, Department of obstetrics and gynecology and Human Potential Translational Research Programme, National University Singapore, Singapore
[i] Singapore Institute for Clinical Sciences (SICS), Agency for Science, Technology and Research (A*STAR), Singapore

HIGHLIGHTS

- Higher resilience was associated with lower frailty index level in older age.
- The most frequently identified adversity in older age was personal illness.
- Type of the adversity was related to the association between resilience and frailty.

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Keywords:
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ABSTRACT

Objectives: Resilience, a capacity to cope with adversity, has been linked to better functioning and health in older age. However, little is still known about resilience in relation to frailty. We explored whether resilience would be associated with frailty in older age and if we would observe differences in association between resilience and frailty according to the type of adversity.

Methods: The study included 681 participants from the Helsinki Birth Cohort Study, born in Helsinki between 1934 and 1944. Adversities in older age and resilience were assessed between 2015 and 2018 with the Hardy-Gill resilience scale, scores ranging from 0 (low) to 18 (high resilience). Frailty was assessed in 2017–18 by using a deficit accumulation-based Frailty Index with a scale from 0 to 1. Adversities were coded into categories by using a data-driven approach. A linear regression analysis was used to explore the association between resilience and frailty.

Results: Resilience was inversely associated with frailty in older age (β -0.009, 95% CI -0.011 to -0.007, $p<0.001$). The association was observed for all other type of adversities except adversity in relationships and economical adversity.

Discussion: A higher resilience was related to lower levels of frailty in older age. Differences in association between resilience and frailty were observed according to the type of adversity. Focusing on the type of adverse events and the capacity to "bounce back" after an adversity in older age may reveal new perspectives on how to prevent and postpone frailty.

* Corresponding author.
E-mail address: sini.m.stenroth@student.jyu.fi (S.M. Stenroth).

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1. Introduction

As the population ages, frailty is becoming an increasingly recognized public health concern (Dent et al., 2019; Hoogendijk et al., 2019). According to a recent systematic review, the estimated prevalence of frailty in adults aged ≥50 years was 24% (O'Caoimh et al., 2021). Frailty can be defined as a state where accumulating health deficits (Mitnitski, Mogilner & Rockwood, 2001) predispose individuals to e.g., falls, recurrent hospital admissions, disability, and premature mortality (Hoogendijk et al., 2019). Frailty is characterized by dysregulation in multiple organ systems and progressive decline in physiological reserve (Clegg, Young, Iliffe, Rikkert & Rockwood, 2013; World Health Organization, 2017). Research on frailty has primarily focused on its underlying biological pathways and related physical factors. By contrast, psychosocial components affecting frailty progression have been little studied (Bessa, Ribeiro & Coelho, 2018; Mulasso, Roppolo, Giannotta & Rabaglietti, 2016).

Most individuals are exposed to adverse events during the life course (Bonanno, 2004). In older age, the most commonly faced adverse events are e.g., deaths and illnesses of family members, personal health problems or other non-medical events (Hardy, Concato & Gill, 2002). These events or circumstances are often traumatic and disturbing (Bonanno, 2004) although several factors such as the type and timing (Nelson, Bhutta, Harris, Danese & Samara, 2020) as well as the intensity and perceived stressfulness (Hardy et al., 2002; Lindert et al., 2020) affect coping with these adverse events. Adverse events are closely related to the concept of resilience (Ungar & Theron, 2020). Resilience, i.e. coping with adversity, can be described as a capacity to thrive or "bounce back" and adapt positively regardless of an adverse event (Windle, 2011). According to Ungar and Theron (Ungar & Theron, 2020) resilience should be considered as a multisystemic process where psychological, biological, social, and ecological systems interact in order to regain, sustain and improve individual's mental health after an adversity. Resilience has been linked to better health (Freitag & Schmidt, 2016; Wiles et al., 2019) and functioning (Manning, Carr & Kail, 2016) in older age and might be seen as a potential protective factor against the development of frailty, yet previous research findings are scarce (Freitag & Schmidt, 2016; Kohler, Rametta, Poulter, Vogrin & Yates, 2020; Lenti et al., 2022; Wong et al., 2021). Additionally, Haapanen et al. (2018) showed in a previous study that childhood adverse events were related to an increased frailty risk in older age. The first aim of this study was to explore how resilience is associated with frailty in older age. Furthermore, we investigated if the association between resilience and frailty can be observed in different subgroups according to the type of adversity.

2. Materials and methods

2.1. Participants

We used data from the Helsinki Birth Cohort Study (HBCS) which includes 8760 men and women, who were born in Helsinki University Hospital between the years 1934–1944 and who were still living in Finland in 1971 (Eriksson, Forsén, Osmond & Barker, 2003). HBCS data consists of up to three clinical examinations and a postal survey carried out between 2001 and 2018 complemented with information from several national registers (e.g., hospital admissions, drug purchases, socio-economic factors) (Barker & Kajantie, 2005; Haapanen et al., 2022). At baseline, 2904 individuals from the HBCS cohort were randomly selected and 2003 participated in the first clinical examinations in 2001–04. Participants still alive and living within 100 km distance from the study clinic in Helsinki were invited to participate in the follow-up clinical examinations in 2011–13 (invited $n = 1404$; participated $n = 1094$) and in 2017–18 (invited $n = 1174$; participated $n = 815$) (Barker & Kajantie, 2005; Eriksson et al., 2015; Haapanen et al., 2022). In addition to the baseline clinical cohort, all surviving participants ($n = 1577$) received a mailed questionnaire in 2015 and $n = 1153$ replied. We used HBCS data from the postal survey in 2015 and from the clinical examination conducted in 2017–2018. Altogether, 681 participants had information on resilience in 2015 or 2017–18 and had the Frailty Index calculated in 2017–18.

The Helsinki Birth Cohort Study has received an ethical statement from the Coordinating Ethics Committee and that of a local hospital's Institutional Review Board. The present study follows the guidelines of the new European parliament General Data Protection Regulation 2016/679 (GDPR). All participants in HBCS have signed a written informed consent prior to participation.

2.2. The hardy-gill resilience scale

The Hardy-Gill resilience scale (Hardy et al., 2002) consists of three parts: identifying the most stressful adverse event, rating the level of stressfulness of the adverse event and assessing the consequences of the adversity (i.e., resilience) with structured questions. The scale is based on the resilience module of the Asset and Health Dynamics (AHEAD) Study (Soldo, Hurd, Rodgers & Wallace, 1997). The participants were first asked to identify the most stressful adverse event during the past five years with an open-ended question. Then, the participants were asked to rate the level of stressfulness of the identified adverse event by using a visual analogue scale. Stressfulness of the event was reported by making a mark along a continuous line starting from "not particularly" and ending to "extremely" (Hardy et al., 2002). To assess the exact value, the 140-mm line was measured from the start to the point the respondent marked. A higher value indicated greater stressfulness of the adverse event. In addition, nine structured questions were asked about the perceived consequences of and coping with the adverse event (e.g., "After this event, how much more discouraged were you? / How much harder was it to get everyday things done?'') (Hardy et al., 2002). Questions were assessed by four-point Likert scale or dichotomous yes/no responses (Hardy et al., 2002). These nine questions were used to develop a 6-item resilience scale with scores ranging from 0=low to 18=high, for a detailed description, see Hardy et al., 2002 and 2004 (Hardy et al., 2002, 2004). Characteristics of the participants were compared across three equal groups based on the data, which indicated low (0–9 points), intermediate (10–13) and high resilience (14–18). The scale was assessed at two time points during the years 2015–2018 (in the postal survey and as a part of clinical examination). If the participant had answered the scale at both time points, we selected systematically the resilience score which was linked to the adverse event that the participant rated as the most stressful.

2.3. Deficit accumulation-based frailty index

A 41-item deficit accumulation-based Frailty Index (FI) (Mitnitski et al., 2001) was created based on assessments from the clinical examination in 2017–18. FI presents frailty as the accumulation of health-associated deficits where higher FI scores indicate greater levels of frailty (Mitnitski et al., 2001). The FI constructed for the HBCS is described in detail in Haapanen et al. (Haapanen et al., 2022). The FI combines 41 health-associated deficits from the RAND 36-Item Health Survey (1992) including health-related limitations in daily activities (e.g., carrying groceries and climbing stairs), bodily pain, and emotional well-being, questions from Beck Depression Inventory (Beck, Ward, Mendelson, Mock & Erbaugh, 1961), clinical test results (e.g., body mass index, cholesterol levels) and self-reported or register-based information (reimbursement of medicine expenses) about chronic illnesses (Table S1). The variables chosen for FI were based on a standard procedure for creating a Frailty Index by Searle et al. (Searle, Mitnitski, Gahbauer, Gill & Rockwood, 2008). Participants' FI level was calculated if he/she had information on at least 33 of 41 deficits included, and counted by summing the number of deficits and then dividing this count by the total number of deficits considered to yield an index ranging from

0 to 1 (Haapanen et al., 2022). To evaluate the frail state, a cut-point of ≥ 0.25 was created based on previous literature (Rockwood, Andrew & Mitnitski, 2007; Song, Mitnitski & Rockwood, 2010).

2.4. Covariates and characteristics

Covariates included were age, sex (male or female), socioeconomic status (SES) in adulthood, and marital status based on earlier literature (Bonanno & Mancini, 2008; Windle, 2011). SES and highest level of education were obtained from Statistics Finland. SES was categorized as upper official, lower official, self-employed and manual worker based on the original social classification of socioeconomic groups by Statistics of Finland (Central Statistical Office of Finland, 1989) and highest level of education as upper tertiary, lower tertiary, upper secondary and basic or less or unknown. Information on participant's age, self-reported marital status (married, unmarried, divorced or widowed), and financial situation (very good, good, average, poor or very poor) were collected at the same time point as the resilience score.

2.5. Qualitative data analysis

To gain knowledge about the type of adverse events the participants identified, the answers regarding the most stressful adverse event were coded into categories by following the logic of a basic content analysis (Schreier, 2012). The answers were short descriptions of 1–4 words (e.g., "death of a spouse" or "own sickness"). First, the answers in which the participants identified the most stressful adverse event during the past five years, were considered as meaning units and coded inductively by two researchers (SMS and KP) based on the general type of the adversity (e.g., "death" or "sickness" or "injury"). If the respondent listed more than one adversity (9.3%), only the first answer was considered and extracted as relevant data. Then the coded answers were further categorized based on whether the adverse event happened to the self or to someone else (e.g., a spouse, a child). In final stage, the coding and emerged categories were discussed by the same researchers until a consensus was reached. The analysis was conducted by using ATLAS.ti software (V22.2.5, Scientific Software Development GmbH).

The result of the analytical process comprised ten categories (death of a close relative, illness of a close relative, economical adversity, adversity in relationships, personal injury, personal illness, adversity related to the ageing process, death of a friend, adversity related to living situation, and other). Close relative refers to a respondent's spouse, a parent, a child, a grandchild, a sibling, or the spouse of any such person. Economical adversity included material losses and lack of sufficient money, and adversity in relationships worrying about loved ones and conflicts. Adversity related to the ageing process was merged from two minor sub-categories; having to give up something (e.g., driving, a hobby, a job) because of ageing, and decline in health or functional capacity. Adversity related to living situation included mainly moving house and renovation. Other adversity comprised a large scale of minor every-day adverse events (e.g., missing the bus) to larger losses (e.g., losing a pet).

2.6. Statistical analyses

Main characteristics were analysed by using the $\chi 2$-test for categorical variables and Kruskall-Wallis test for continuous variables. We used linear regression analyses to assess the association between resilience and frailty. We performed pooled analyses as there was no evidence of an interaction between sex and resilience on frailty ($p = 0.221$). The first model was adjusted by sex and age. The second model was further adjusted by adulthood SES. In the third final model, we added marital status to the analysis as adjustment. The ten adverse event categories were recoded into five based on the type of the adverse event and the level of perceived stressfulness as presented in Fig. 1. Linear regression analysis was performed in subgroups based on these recoded adversity categories by using the same models as in the main analysis. Maximum of three missing values in the Hardy-Gill resilience scale were imputed ($n = 40$, 5.9%) by using Multiple Imputation procedure based on available information on the scale. The analyses were performed using SPSS (IBM SPSS Statistics for Windows, Version 28.0 IBM Corp.).

3. Results

The characteristics of the study population according to resilience are presented in Table 1. The mean age of the participants was 75.2 years (SD 3.0). Men represented 43.0% of the study population and had significantly higher resilience compared to women. Most of the participants were married (70.2%). Participants with better financial situation had higher resilience than those who were financially less well-off. No significant differences were found in age, adulthood SES, and highest level of education between the groups of high, intermediate, and low resilience. Baseline characteristics were compared amongst the study sample and those who were not invited to clinical follow up examinations from 2011 to 13 onwards, could not be contacted, or declined. Compared to the study sample, the ones who did not take part were less likely low officials and more likely labourers. They had higher FI level, but similar self-rated health except more likely of those with poor health, from baseline to follow-up examination in 2011–13 (Table S2).

The most frequently identified adversity was personal illness (21.1%) followed by illness of a close relative (19.0%) and death of a close relative (15.7%). Main adverse event categories according to the Hardy-Gill resilience score and the FI level listed from the highest perceived stressfulness to the lowest are presented in Table 2. The participants who faced adversity related to living situation had the highest resilience score (mean 13.17, SD 3.75) and the lowest FI level (median 0.17, IQR 0.12–0.2). In contrary, those who faced adversity related to the ageing process had the lowest resilience score (mean 8.88, SD 4.39) and the highest FI level (median 0.36, IQR 0.23–0.44). The participants who had encountered personal injury had lower resilience score (mean 9.47, SD 3.99) than those with adversity related to living situation, even though these participants had an equally low FI level median score (0.17, IQR 0.12–0.33).

Results on the association between resilience and frailty are presented in Table 3. After adjusting the model for age and sex, one point increase in resilience score was associated with 0.009 lower FI level (β −0.009, 95% CI −0.011 to −0.007, $p<0.001$). When the model was further adjusted for adult SES and, in the final stage, for marital status, the association between resilience and frailty remained (β −0.009, 95% CI −0.011 to −0.007, $p<0.001$).

As a sensitivity analysis we excluded the participants who had identified the most stressful adversity as personal illness or decline in health or functional capacity (subcategory in adversity related to the ageing process) since these categories were partly overlapping with items in the FI (Table S3). The sensitivity analysis showed that the association between resilience and frailty remained significant after adjustments for age, sex, adult SES, and marital status (β −0.008, 95% CI −0.011 to −0.006, $p<0.001$). The type of the adverse event was related to the association between resilience and frailty. Regarding to the five adversity categories, in the category which was perceived as the second most stressful and included adversity in relationships and economical adversity, the association between resilience and frailty was non-significant (β −0.004, 95% CI −0.008 to 0.001, $p = 0.106$). Conversely, the significant association between resilience and frailty was observed in all the other adversity categories, as presented in Table 4 and in Figure S1.

4. Discussion

We observed a negative linear association between resilience and frailty in older age that was independent of age, sex, adult SES, and

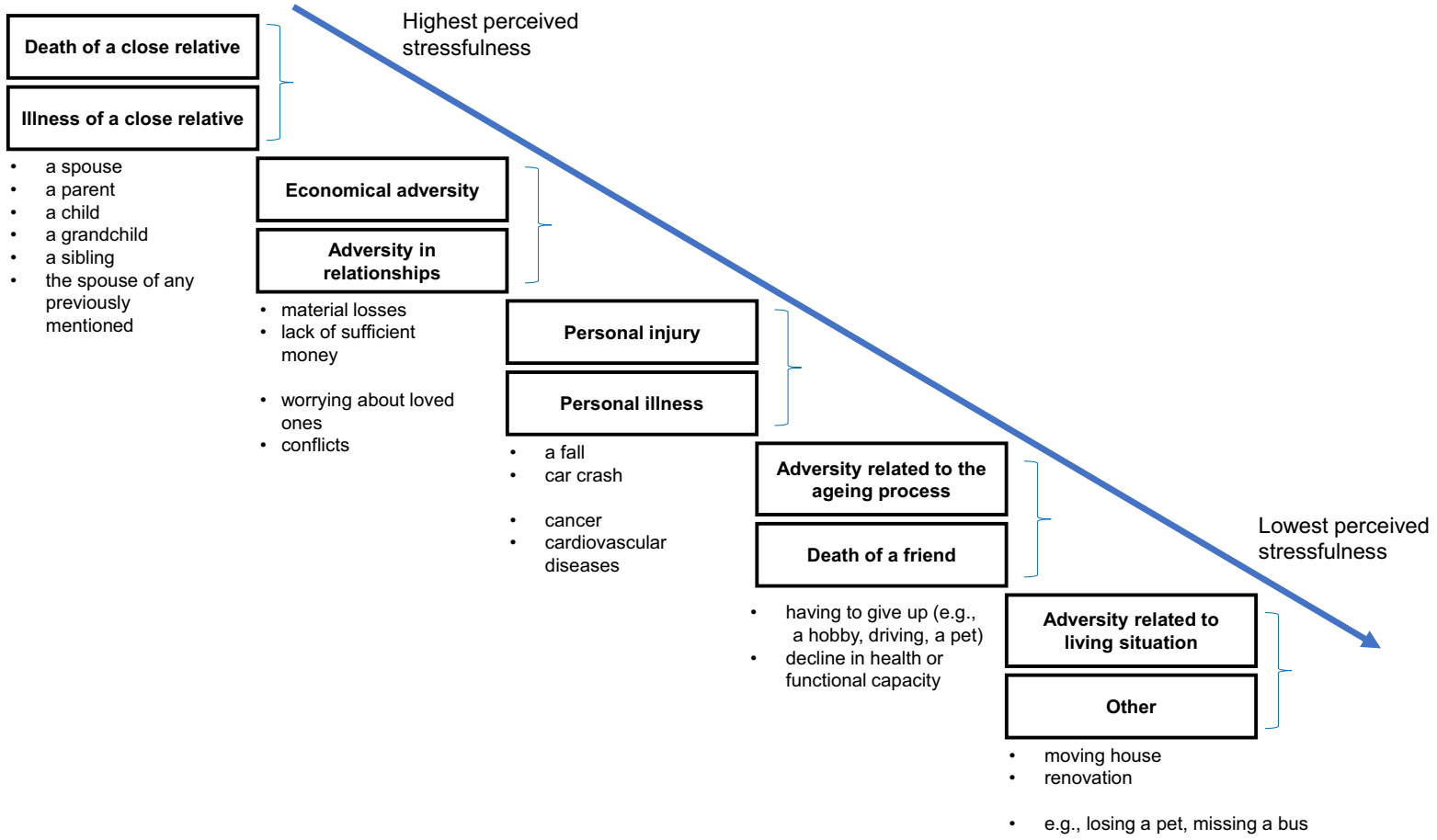

Fig. 1. The adverse event categories and recoding based on perceived stressfulness.

Table 1
Characteristics of the study population according to low, intermediate and resilience.

	Total $n = 681$	Groups of resilience[a] Low $n = 230$	Intermediate $n = 238$	High $n = 213$	p-value
Age, years mean (SD)	75.2 (3.0)	75.6 (3.2)	75.1 (3.0)	74.9 (2.7)	0.164
Sex, n (%)	681				<0.001
Male	293 (43.0)	62 (27.0)	105 (44.1)	126 (59.2)	
Female	388 (57.0)	168 (73.0)	133 (55.9)	87 (40.8)	
Adult SES, n (%)	681				0.65
Upper official	132 (19.4)	43 (18.7)	43 (18.1)	46 (21.6)	
Lower official	328 (48.1)	117 (50.8)	114 (47.9)	97 (45.5)	
Self-employed	61 (9.0)	16 (7.0)	27 (11.3)	18 (8.5)	
Manual worker	160 (23.5)	54 (23.5)	54 (22.7)	52 (24.4)	
Highest level of education, n (%)	681				0.49
Upper tertiary	123 (18.1)	35 (15.2)	51 (21.4)	37 (17.4)	
Lower tertiary	87 (12.8)	27 (11.7)	28 (11.8)	32 (15.0)	
Upper secondary	111 (16.3)	36 (15.7)	41 (17.2)	34 (16.0)	
Basic or less or unknown	360 (52.8)	132 (57.4)	118 (49.6)	110 (51.6)	
Marital status, n (%)	675				<0.001
Married	474 (70.2)	133 (58.1)	171 (72.1)	170 (81.3)	
Unmarried	26 (3.9)	9 (3.9)	8 (3.4)	9 (4.3)	
Divorced or widowed	175 (25.9)	87 (38.0)	58 (24.5)	30 (14.4)	
Financial situation, n (%)	673				0.002
Very good	80 (11.9)	17 (7.4)	29 (12.3)	34 (16.3)	
Good	303 (45.0)	95 (41.5)	109 (46.2)	99 (47.6)	
Average	261 (38.8)	99 (43.2)	92 (39.0)	70 (33.7)	
Poor or very poor	29 (4.3)	18 (7.9)	6 (2.5)	5 (2.4)	

Note. SD=standard deviation. SES=socioeconomic status.
[a] Groups of resilience: low 0–9 points, intermediate 10–13 points, high 14–18 points.

Table 2
Main adverse event categories from highest perceived stressfulness to lowest according to the Hardy-Gill resilience score and Frailty Index level.

	Total $n = 681$		Hardy-Gill Resilience score mean (SD)		Frailty Index median (IQR)	
Main adverse event, n (%)	680					
Death of a close relative[a]	107	(15.7)	9.64	(3.46)	0.20	(0.14–0.29)
Illness of a close relative[a]	129	(19.0)	11.35	(3.32)	0.21	(0.15–0.30)
Economical adversity	25	(3.7)	10.92	(3.95)	0.24	(0.16–0.38)
Adversity in relationships	94	(13.8)	10.71	(3.97)	0.20	(0.15–0.26)
Personal injury	30	(4.4)	9.47	(3.99)	0.17	(0.12–0.33)
Personal illness	143	(21.1)	10.57	(4.27)	0.23	(0.16–0.32)
Adversity related to the ageing process	26	(3.8)	8.88	(4.39)	0.36	(0.23–0.44)
Death of a friend	26	(3.8)	12.08	(2.00)	0.23	(0.16–0.31)
Adversity related to living situation	58	(8.5)	13.17	(3.75)	0.17	(0.12–0.25)
Other	42	(6.2)	12.36	(3.78)	0.19	(0.15–0.24)

Note. SD=standard deviation. IQR=interquartile range.
[a] Close relative= a spouse, a parent, a child, a grandchild, a sibling, or the spouse of any such person.

marital status. As a novel finding, this research suggests that alongside with potential causal pathway, there may be a qualitatively significant association between the type of adversity encountered and how it is lived and experienced. This again may be linked with resilience in older people living with frailty.

The inverse association between resilience and frailty is consistent with previous research findings in community-dwelling older adults (Freitag & Schmidt, 2016), older patients with liver cirrhosis (Wong et al., 2021), hospitalised older patients (Lenti et al., 2022), and patients in geriatric rehabilitation (Kohler et al., 2020). Even though causal inferences between resilience and frailty cannot be made, the assumption that emerges from these findings is the possibility to decrease or delay the progression of frailty by strengthening resilience discussed also by Wong et al. (2021). This view is also supported by Majnarić et al. (2021) who suggest the possibility for a causal pathway between low resilience and frailty; pathophysiological mechanisms underlie low resilience, which may lead to deterioration of health in older age.

A significant inverse linear association between resilience and frailty was found in all other adversity categories except adversity in relationships and economical adversity. This finding raises a question, how adversity in relationships, which mainly included worrying about a close relative, and economical adversity, mainly material losses, differ from other categories. Considering the variability and complexity of adverse events, simple presumptions cannot be made. In addition to perceived stressfulness and the type of adversity, the duration, onset and intensity of the adverse event are all related to resilience (Carr, 2020; Hardy et al., 2002; Lindert et al., 2020), and subsequently, to the relationship between resilience and frailty. Furthermore, different adversities require diverse coping strategies and resilience resources (Hildon, Smith, Netuveli & Blane, 2008, 2010; Windle, Bennett, MacLeod & team, 2020) which in turn influence the observed association between resilience and frailty.

Regardless of different perspectives in the concepts of resilience and frailty, a certain consistency can be found. Frailty is characterized by increased vulnerability to stressors (Hoogendijk et al., 2019) whereas resilience can be seen as a successful adaptation to stressors (Hale, Shah & Clegg, 2019). Both resilience and frailty are considered as multi-level or multidynamic concepts (Clegg et al., 2013; Denckla et al., 2020) and have certain analogies, particularly to intrinsic capacity (Cesari et al., 2018). Intrinsic capacity, defined as individual's physical and mental capacity (World Health Organization, 2017), may act as an integrating concept for resilience and frailty. WHO (2017) refers to resilience as an aim that could be enhanced by developing intrinsic capacity. Strengthening resilience may mitigate the loss in physiological reserve in older age. In other words, higher resilience might ameliorate or postpone health deficits related to the frailty syndrome.

4.1. Strengths and limitations

The findings of this study further our knowledge about the association between resilience and frailty in older age. In contrast to previous studies (Freitag & Schmidt, 2016; Kohler et al., 2020; Lenti et al., 2022; Wong et al., 2021), we studied a larger sample and in a longitudinal cohort setting. The Hardy-Gill resilience scale (Hardy et al., 2002) differs from other scales measuring resilience in older people by identifying the adverse event rather than focusing on resilience in general. We were able to use this information to deepen our insight on how adversity was related to frailty in older age. By investigating qualitatively the type of the adversity, we extended the perspective on adverse events in older age. We used a deficit accumulation-based Frailty Index as a measurement for assessing frailty instead of the frailty phenotype (Fried et al., 2001). The FI may have an advantage to more sensitively discriminate frailty than the frailty phenotype (Blodgett, Theou, Kirkland, Andreou &

Table 3
Unstandardized regression coefficients (β) and 95% confidence intervals (CI) for frailty according to resilience.

	Model 1 β (95% CI)[a]	p	Model 2 β (95% CI)[a]	p	Model 3 β (95% CI)[a]	p
All	−0.009 (−0.011,−0.007)	<0.001	−0.009 (−0.011,−0.007)	<0.001	−0.009 (−0.011,−0.007)	<0.001
R^2	0.164		0.169		0.171	

Note. [a]Model 1 adjusted for age and sex. Model 2 adjusted for Model 1 plus adult SES. Model 3 for Model 2 plus marital status.

Table 4
Unstandardized regression coefficients (β) and 95% confidence intervals (CI) for frailty according to resilience, stratified with adversity categories from the highest perceived stressfulness to the lowest.

	Model 1 β (95% CI)[a]	p	Model 2 β (95% CI) [a]	p	Model 3 β (95% CI)[a]	p
Death or illness of a close relative[b]	−0.008 (−0.012,−0.004)	<0.001	−0.008 (−0.012,−0.004)	<0.001	−0.008 (−0.013,−0.004)	<0.001
R^2	0.174		0.175		0.180	
Adversity in relationships and economical adversity[b]	−0.003 (−0.008,0.001)	0.139	−0.004 (−0.008,0.001)	0.116	−0.004 (−0.008,0.001)	0.106
R^2	0.098		0.143		0.162	
Personal injury or illness[b]	−0.010 (−0.014,−0.007)	<0.001	−0.010 (−0.014,−0.007)	<0.001	−0.010 (−0.014,−0.007)	<0.001
R^2	0.171		0.192		0.192	
Adversities related to the ageing process and death of a friend[b]	−0.021 (−0.028,−0.014)	<0.001	−0.021 (−0.028,−0.013)	<0.001	−0.021 (−0.029,−0.013)	<0.001
R^2	0.420		0.420		0.425	
Adversities related to living situation and other[b]	−0.008 (−0.012,−0.004)	<0.001	−0.008 (−0.012,−0.004)	<0.001	−0.008 (−0.012,−0.004)	<0.001
R^2	0.186		0.187		0.220	

[a] Model 1 adjusted for age and sex. Model 2 adjusted for Model 1 plus adult SES. Model 3 for Model 2 plus marital status.
[b] Illness or death of a close relative $n = 236$, adversity in relationships and economical adversity $n = 119$, personal illness or injury $n = 173$, adversity related to the ageing process and death of a friend $n = 52$, adversity related to living situation and other $n = 100$.

Rockwood, 2015).

With regards to limitations of this study, particular issues should be mentioned. The FI used in this study did not include deficits related to cognition due to data availability. Nevertheless, the advantage of the FI is that it can identify older adults at greater risk of frailty albeit limitations in different domains of health deficits (Rockwood, Mitnitski, Song, Steen & Skoog, 2006). From the Hardy-Gill Resilience scale, we included only the first identified adversity as relevant data. This decision should be considered as a potential limitation. Participants who answered more than one adverse event may have experienced adversities equally (qualitatively) significant. However, only a minor part of participants (9.3%) answered several adverse events. Adversities related to personal illness or decline in health or functional capacity were overlapping with certain health deficits included in the FI. We addressed this issue by conducting a sensitivity analysis which excluded these specific adversities from the data. In a cross-sectional study, we cannot rule out the possibility that frailty is associated with resilience rather than vice versa. Considering the complex nature of both frailty and resilience, the relationship might be bidirectional. A loss of participants, a distinctive feature in studies concerning older adults, should be noticed. However, participants in follow-up examinations had quite similar self-reported health compared to those who did not take part. Furthermore, in HBCS, the participants presented individuals who were born in Helsinki during the years 1934–44 and thus the findings may not be generalised to other populations.

5. Conclusions

In conclusion, this research suggests a consistent inverse association between resilience and frailty. We observed differences in association between resilience and frailty according to the type of adversity. In the future, more studies should further explore the relationships between adverse events, resilience, and frailty.

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CRediT authorship contribution statement

Sini M. Stenroth: Formal analysis, Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Katja Pynnönen:** Formal analysis, Writing – review & editing. **Markus J. Haapanen:** Methodology, Writing – review & editing. **Pirjo Vuoskoski:** Formal analysis, Writing – review & editing. **Tuija M. Mikkola:** Data curation, Writing – review & editing. **Johan G. Eriksson:** Data curation, Writing – review & editing. **Mikaela B. von Bonsdorff:** Conceptualization, Formal analysis, Methodology, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2023.105119.

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