Review Article

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OPEN

The comprehensive frailty assessment instrument enables to detect multidimensional frailty in community dwelling older people

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Background: In an ageing society, the concept of frailty in older persons is a fast growing research area in gerontology and geriatric medicine. Some researchers consider frailty as a clinical, pure biomedical or physical problem. Other scholars suggest to give more attention to the psychological aspects of frailty because conceptualizing frailty as a pure medical problem is neglecting both the capacities of older people themselves to withstand stress and their experiences. In response to this, the Comprehensive Frailty Assessment Instrument was developed and assesses physical, psychological, social and environmental frailty. Although the CFAI is validated and captures four domains of frailty, the lack of cut-offs hampered the use of the instrument in practice. Therefore, the aim is to develop cut-offs for each frailty domain and to assess their construct validity.

Methods: Two-step cluster analysis on a dataset of 33629 community dwelling older people in Belgium.

Results: Cut-offs for the total score on frailty and the four domains were developed. In order to assess construct validity, these groups were subsequently analysed with variables for which there is evidence in literature for their association with frail. The developed cut-offs are in line with previous findings, pointing towards construct validity of the cut-offs.

Conclusion: This study provides support for the use of the CFAI and its cut-offs in order to detect community dwelling older people.

Keywords: Frailty, Multidimensional frailty, Older people, Instrument, Community dwelling

Introduction

In an ageing society, the concept of frailty in older persons is a fast growing research area in gerontology and geriatric medicine. Since the first definition was proposed by the Federal Council on Aging (USA) ('persons, usually but not always, over the age of 75 who because of an accumulation of various continuing problems often require one or several supportive services in order to cope with daily live' [1], many scholars focus on its screening, causes, risk factors and adverse outcomes [2]. Some researchers consider frailty as a clinical, pure biomedical or physical problem [3]. In this approach, frailty is considered as a medical/clinical syndrome in which the underlying physiological and biological processes result in multiple clinical manifestations [4]. Fried, one of the leading scholars regard frailty from a physical point of view and developed the phenotype of frailty [5]. This phenotype has received international attention [6-8]. Criteria used by Fried to define frailty are: weight loss, endurance, inactivity, gait speed and hand grip strength. Besides these criteria, a wide range of other physical problems has been linked to frailty. Although there is a growing consensus that frailty can be distinguished from disability or comorbidity [9-11], a consensus about an operational definition of frailty is still lacking [2,10,12-15]. The absence of a consensus has leaded to different concepts of frailty, different assessment instruments and therefore also different prevalence rates of frailty. For instance, van Iersel and Olde Rikkert [16] reported prevalences of frailty in patients admitted to an acute geriatric ward or old age psychiatry ranging between 36% and 88%, according to the tool used. This could be a problem when Western welfare policies start using frailty as a tool for funding frail older people based on their level of frailty, as is the case for instance in Austria [17].

Other scholars suggest to give more attention to the psychological aspects of frailty [18] because conceptualizing frailty as a pure medical problem is neglecting both the capacities of older people themselves to withstand stress and their experiences [19]. As a consequence, some

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psychological indicators like mastery, depression and cognition [20] or anxiety, sadness, cognitive deficiency and management capacities [21] were introduced next to physical measurements.

This bio-psychological approach was criticized for its lack of social indicators, neglecting thereby the complex interplay of bio-psycho-social factors in frailty [22]. As a consequence, social indicators like social support [23] were introduced as well, next to biomedical and psychological indicators. As many Western policies focus on ageing in place while at the same time reduce financing and formal support, Bunt et al. [24] conclude that social frailty becomes very important. Some conceptual models make an attempt to be integrative, as they aim to apprehend all domains of functioning, i.e. the physical, cognitive, social and psychological domain.

Recently, de Vries et al. developed the Evaluative Frailty Index for physical activity (EFIP) [25], which assesses physical, psychological and social functioning and health and showed to be a reliable a valid instrument to evaluate physical activities of a frail older person.

Within this integrative approach, the Comprehensive Frailty Assessment Instrument (CFAI) was developed based on a dataset of 33,629 community dwelling older persons [26]. The instrument assesses frailty as a multidimensional concept like suggested by different scholars [20,27-31]. The Comprehensive Frailty Assessment Instrument, a self-administer instrument developed for the detection of frailty in the community, measures the physiological, psychological, social and environmental domain of frailty. The domain concerning environment was added as there is a tendency in ageing research to decontextualize human ageing from the environment [32] although when ageing, older people highly depend on the sustainability of their housing conditions and environment [33].

The CFAI is validated and captures four domains of frailty, but the lack of cut-offs hampered the use of the instrument in practice, where classification of individuals is often needed and is rather difficult using a continuous scale. In literature it is suggested that in order to capture the dynamic nature of frailty, a continuous scoring system or an ordinal scoring system on multiple levels would be preferred [34]. A systematic review on 20 outcome instruments measuring frailty, showed three types of scoring systems were used [35]. Half of those instruments use a dichotomous scoring system (frail or non-frail), five instruments used three classes (robust, pre-frail, frail) and the other instruments did not use a cut-off point. Some scholars argue that binary classification (frail or non-frail) misses the significance of older people's experience of accumulated loss [36].

Therefore, the aim of this study is threefold. First a two-step cluster analysis is used in order to explore frailty profiles in a large dataset of 33,629 community dwelling older people. Given the aforementioned remarks, no assumptions about the number of clusters or cluster membership have been made prior to the analysis. A second aim is to develop cut-offs for each frailty profile. Finally, our aim is to analyze the construct validity of the frailty profiles using variables for which there is evidence in literature that they are associated with frailty.

Methods

Participants

Data originating from the Belgian Ageing Studies (BAS) were used. The BAS, which have been conducted in the Dutch-speaking part of Belgium since 2004, collects information from community-dwelling older people aged 60 and over about their perceptions on various aspects related to the quality of life and living conditions in later life through a highly structured survey. Frailty is one of the topics assessed with the self-administered questionnaire. Next to these topics, descriptive information, such as age, gender, income, marital status and educational level [37]. Since the project started, older respondents living in 142 municipalities have been included. In each municipality, addresses were randomly selected from population registries. The sample was stratified, using quotas for gender and age (60 to 69. 70 to 79 and 80+ years) to ensure that the sample matched the makeup of the underlying population in the community. This type of sampling ensured that the 80+ age group was adequately represented. The sampling fraction depended on the size of the municipality (range N=182 to N=1.592) and the first response rate ranged between 65 and 85%. All questionnaires were entered using Microsoft Access, and the analyses were performed using IBM SPSS 23 (IBM, SPSS, Armonk, NY: IBM Corp, 2016). The dataset (N=33.629) on which the CFAI was developed [26] is used to perform the two-step cluster analysis. As our intention was to validate the clusters using variables for which there is evidence in literature that they are associated with frailty (age, gender income, marital status and educational level), respondents non responding to one of those variables were deleted from the dataset, resulting in a dataset of 28.245 community dwelling older people.

Measures

Description of the CFAI: As mentioned above, frailty was assessed within the BAS using the CFAI. This multidimensional instrument was validated [26] in a second order confirmatory factor analyses and showed good fit indices. Afterwards, the CFAI was cross validated with the Tilburg Frailty Indicator [38]. The CFAI measures 4 domains of frailty.

For the physical domain of frailty, participants were asked to indicate how long they had been hampered by their health status in performing the following activities: 'Less demanding activities like carrying shopping bags', 'Walking up a hill/stairs', 'Bending or lifting' and 'Going for a walk'. The answer and scoring options are 0="not at all", 1="3 months or less" and 2="more than 3 months", resulting in a total score ranging from 0 to 8.

The psychological domain was captured by measuring mood-disorders and emotional loneliness. Mood disorders were assessed using the following propositions: 'Feeling unhappy', 'Losing self-confidence', 'Unable to cope with problems', 'Feeling pressure' and 'Feeling worth nothing anymore'. The answer and scoring options are 0="not at all", 1="not more than usual", 2="more than usual", 3="considerably more than usual". Summing these scores resulted in a total score ranging from 0 to 15. The second measurement in this domain was emotional loneliness. The propositions measured were: 'I experience a general sense of emptiness', 'I miss having people around me' and 'I often feel rejected'. The answer and scoring options are: 0='I completely disagree', 1='I disagree', 2='I neither agree nor disagree', 3='I agree', 4='I completely agree'. Adding the scores on these three propositions resulted in a total score ranging from 0 to 12.

The social domain of frailty also consisted of two measurements. The first measurement assessed social loneliness and is measured through 3 propositions: 'There are plenty of people I can lean on when I have problems', 'There are many people I can trust completely' and 'There are enough people I feel close to'. As these propositions are positively stated scoring options were reversed: 4='I completely disagree', 3='I disagree', 2='I neither agree nor disagree', 1='I agree', 0='I completely agree'. Adding the scores on these three propositions resulted in a total score ranging from 0 to 12. Furthermore, to obtain an insight into the social support network, the participants could

fill in which of the following persons they could rely on for help if necessary: partner, son, daughter-in-law, daughter, son-in-law, grandchildren, brother or sister (-in-law), family, neighbors and friends. For each person the respondent can rely on, a score of 0 is granted otherwise the score is 1. Counting all these scores resulted in a total score ranging from 0 to 10.

Finally, the environmental domain consisted of five propositions assessing the push factors of the respondent's actual housing and environmental conditions: 'My house is in a bad condition', 'My house is not comfortable', 'It is difficult to heath my house', 'There is insufficient comfort in my house' and 'I do not like the neighborhood'. The answer and scoring options are: 0='I completely disagree', 1='I disagree', 2='I neither agree nor disagree', 3='I agree', 4='I completely agree'. Adding the scores on these three propositions resulted in a total score ranging from 0 to 20.

Socio demographic and economic indicators: Besides the CFAI, socio demographic and economic indicators like age, gender, household income and educational level were assessed. Indeed, in literature, frailty is associated with advanced age [14,39-41], female gender [11,39,40,42,43], low income and low education [44].

Calculation of the scores of the CFAI: To stress the importance of the multidimensional nature of frailty [31], the purpose of the CFAI was not only to assess 4 domains of frailty, but also to give equal weight to the four domains. **Table 1** gives an overview of those domains, their measurements, their scores, their weight within the domain (WWD) and the weight of the domain within the total score of the CFAI (DWWT). In **Table 2** the formulas for calculating the domain and total scores that are presented in **Table 1**.

In order to give equal weight to each domain, scores are recalculated using the formula in **Table 2**. As can be seen, the maximum score for the physical domain is 8, which is multiplied with 25 and divided by 8. So the maximum score is set on 25. The same goes for the environmental domain (CFAI_ENV); one measurement counting for 100%. For both the psychological (CFAI_PSYCH) and social (CFAI_SOC), two measurements were used and each measurement is counting for 50% within the respective domain. As a consequence, the score on the psychological domain (CFAI_PSYCH) is obtained as follows. The maximum score of mood disorders is 15. The score of this domain is multiplied with 12.5 and divided by 15. This score is added to the score on emotional loneliness, which is calculated by multiplying the score with 12.5 and divide it with 12. A similar calculation is offered for the social domain.

Subsequently, the total score of the CFAI is calculated by summing the four domain scores. As a consequence, each of the 4 domains contributes for 25% of the total score.

Statistical analysis: In order to explore the presence of natural groups within the sample, a two-step cluster analysis was used. This method allows discriminating natural groups based on metric variables. This classification is a method for organizing a large data set into a small number of groups. As a consequence, the group labels describe similarities and differences in the data [45]. In these analyses, the respondents' scores on the CFAI are automatically hierarchically clustered using Schwarz's Bayesian Criterion. Log-likelihood was used as distance measure. In order to assess the goodness of the proposed cluster solution, the silhouette coefficient, which measures both the cohesion and separation, was used. For each element in a cluster, the average distance to all other elements in its cluster and the average distance to all elements in each of the other clusters is calculated. In an ideal solution, the within-cluster distances are small and the between-cluster distances are large, resulting in a silhouette measure close to the maximum value of 1. If the silhouette measure is negative, the average distance of a case to members of its own cluster is larger than the average distance to cases in other clusters, which is undesirable. The silhouette measure ranges from –1 to +1. Results below 0.2 indicate inappropriate fit, while a score between 0.2 and 0.5 points to reasonable clustering and scores above 0.5 to good clustering [46].

Afterwards, the membership cluster was created and the mean and minimal and maximal value of each cluster was assessed. In order to assess whether the clusters are authentic and valid, these clusters were subsequently analysed with variables for which there is evidence in literature for their association with frailty. A Kruskall-Wallis test was used for variables measured on a ratio level and a chi –square test for variables on a nominal/ordinal measurement level.

Table 1

CFAI domains, measurements and weights

CFAI	DWWT	Measurements	Min-max	WWD
CFAI_PHYS (Physical domain)	25%	Physical items	0-8	100%
CFAI_PSYCH (Psychological domain)	25%	Mood disorders	0-15	50%
		Emotional loneliness	0-12	50%
CFAI_SOC (Social domain)	25%	Social loneliness	0-12	50%
		Social support network	0-10	50%
CFAI_ENV (Environmental domain)	25%	Actual housing/ environment	0-20	100%

Table 2

Formulas for calculating the subdomains of the CFAI

CFAI	Formula
CFAI_PHYS (Physical domain)	[Physical items]*25/8
CFAI_PSYCH (Psychological domain)	[mood disorders]*12.5/15 + [emotional loneliness]*12.5/12
CFAI_SOC (Social domain)	[social loneliness]*12.5/12 + [social support network]*12.5/10
CFAI_ENV (Environmental domain)	[actual housing/enviornment]*25/20

Results

Sample characteristics

The mean age of the respondents was 71.8 years (range: 60-107), 54.3% of the respondents were female, 69.3% of the respondents were married, 20.7% were widowed, and 4.3% were divorced. Regarding income, 16.1% had an income less than €1.000. 37.6% had no or only primary education.

Classification of CFAI total scores

In order to detect groups within the CFAI scores, a two-step cluster analyses was performed on the total scores and the scores of the four sub-domains.

Analysis on the CFAI's total score showed 3 natural classes (average silhouette=0.7), as is printed in **Table 3**. Based on the membership cluster, the cut-offs of each class were calculated using the maximum value per group. Consequently, the CFAI's total score can be divided in 3 classes: no-low, mild and high frail. The advantage of having 3 classes is that older people are not dichotomously classified in frail

or non-frail, thus more refinement is possible. For the sub-domains the same procedure was used. Consequently, all other domains were clustered in to three classes with the physical (CFAI_PHYS) showing a silhouette value of 0.8. and the psychological (CFAI_PSYCH), the social (CFAI_SOC) and the environmental domain showing silhouette values of 0.7. 0.6 and 0;8 respectively, all pointing towards an excellent clustering fit. Afterwards, the cut-offs in each domain were calculated based on the membership cluster (**Table 3**).

The CFAI's total score, ranging from 0 to 100, showed cut-offs of 21,9 between no-low and mild frail and 38.8 between mild and high frail. For all the sub-domains, ranging from 0 to 25, cut-offs were developed as can be seen in **Table 3**. Consequently, this sample showed a prevalence of 22.9% for severe frailty and 33.9% for mild frailty. Looking at the subdomains, 16.5% of the sample scored high on physical frailty, 9.0% scored high on psychological frailty, 20.6% in scored high on social frailty and 14.8% on the environmental domain.

Construct validity of the groups

Despite the use of appropriate statistical analysis in detecting the groups and cut-offs, a further validation against research findings focusing on frailty is appropriate. Therefore, the cut-offs are analysed in relation to age, gender, marital status, income and education (**Table 4**).

First, we elaborate on the total score, (CFAI-total). The highest mean age was found in the group with high frailty and men are less likely to be classified in this group (37.1%). Regarding marital status, the group with the highest frailty contained 32.2% widow(ed) older people. Older people with an income of 1000-1499€ and with no or a low educational level represented the highest proportion in the high frailty group. As the CFAI assesses four domains of frailty, it may be relevant to analyze also how gender, age, income and education differ within the specific domain clusters. As can be derived from **Table 1**, men are less likely to be highly physical and psychological frail then women. For social and environmental frailty, these differences persisted, but are more balanced. Widowed older persons are more classified within the high physical and psychological frail group. Older people with an income of more than 2000 euro and people with higher education are more likely to score high on the social and environmental domain of frailty than on other domains.

Discussion

The aim of this study was to explore the frailty profiles in a larger dataset of 33,629 community dwelling older persons, to develop cut-offs for those profiles and to assess their construct validity. With the CFAI, the conceptualization towards frailty and frailty assessment is

Table 3

CFAI total score's cut-offs and the CFAI subdomains' cut-offs

Variables	CFAI_total 0-100			CFAI_PHYS 0-25			CFAI-PSYCH 0-25			CFAI_SOC 0-25			CFAI_ENV 0-25		
	N	%	cut-offs	N	%	cut-offs	N	%	cut-offs	N	%	cut-offs	N	%	cut-offs
no-low	12252	-43.4	21.9	18380	-65.1	6.3	17718	-62.7	5	9000	-31.9	9.4	15420	-54.6	1.25
mild	9583	-33.9	38.8	5209	-18.4	18.8	7984	-28.3	11.5	13416	-47.5	16	8634	-30.6	7.5
high	6455	-22.9		4656	-16.5		2543	-9		5829	-20.6		4191	-14.8	
Total	28245			28245			28245			28245			28245		

Table 4

CFAI total score and subdomain scores in relation to age, gender, marital status, income and education

Variables	CFAI_total			CFAI_PHYS			CFAI_PSYCH			CFAI_SOC			CFAI_ENV			Total sample
	no-low	mild	high	no-low	mild	high	no-low	mild	high	no-low	mild	high	no-low	mild	high	
Age (mean-years)	69	71.3	75	69.3	73.2	76.9	70.9	72.2	73	71.2	71.4	72.1	71.4	71.5	72.6	71.8
Male-gender (%)	54	47.5	37.1	52.2	43.1	33.3	49.4	44.1	35	48.3	46.9	43.2	45.9	48.3	45.1	45.7
Marital status (%)																
married	80.1	68.9	56.3	75.4	65.1	56	75.2	63.9	50.8	75.7	69.9	63.3	72.2	68.7	61.8	69.3
never married	2.4	4.2	4.4	3.5	4.1	3.5	3.3	4.1	4.2	1	4.3	5.5	3.1	3.8	5.5	3.7
divorced	3.4	4.6	5.4	4.3	4.3	4	3.8	4.5	7.5	2.9	3.9	6.4	3.8	4.7	5.9	4.3
cohabiting	2	2.3	1.7	2.2	2.2	1.3	2.1	1.9	1.7	1.4	2.2	2.3	1.9	2.1	2	2
widow(ed)	12.1	20	32.2	14.6	24.4	35.2	15.6	25.5	35.8	19	19.8	22.5	19	20.7	24.8	20.7
Income (%)																
500-999€	9.3	13.8	23	11.2	17.4	24	13.1	16.9	23.6	13.1	14.7	19	14.3	14.9	21.3	16.1
1000-1499€	29.5	35.9	41.8	32	38.6	43.6	33.2	37.9	42.4	35.4	34.7	37.6	34.2	35.5	40.8	36.2
1500-1999€	24.3	24	19.9	24.3	22.1	18.8	23.5	22.8	17.9	23.4	22.8	21.6	22.9	23.1	20.8	22.3
=>2000	37	26.2	15.4	32.5	21.8	13.6	30.1	22.4	16.1	28.2	27.7	21.8	28.5	26.6	17.2	25.3
Education (%)																
no-low	26.3	32.9	47.7	28.5	39	52.6	32.9	37.7	42.9	35.3	34.1	39.2	35.2	34.1	43.2	37.6
secundary	28.3	29.7	26.9	29	29.5	25.9	28.6	29	28.9	28.9	28.5	29	28.9	27.9	28.6	28.6
high school	23.3	21.2	16.3	22.7	18.9	14.9	20.9	19.7	18.3	19.7	20.8	19.1	20.2	20.9	16.9	19.4
Higher education-university	22.1	16.2	9.2	19.8	12.6	6.5	17.5	13.7	9.8	16.1	16.6	12.7	15.7	17	11.3	13.9

all analysis are significant at p=,000

renewed in several ways. In order to move away from a disease-based approach towards a health-based integrative approach, the CFAI assesses frailty from a multidisciplinary perspective. As suggested by scholars like Armstrong, Stolee, Hirdes, Poss [47], Bergman, Ferrucci, Guralnik, Hogan, Hummel, Karunananthan, et al. [10], Markle-Reid, Brown [31] and Pijpers, Ferreira, Stehouwer, Nieuwenhuijzen Kruseman [48] a multidimensional concept was needed that considers the complex interplay of physical, psychological, social and environmental factors. Indeed, with population ageing and ageing in place, detection of frailty becomes a multidisciplinary issue where different primary health care providers [49] and policymakers can be involved. The CFAI is developed as a screening instrument for assessing frailty in the community on a large scale and does not rely on clinical judgments by high skilled caregivers [26]. The CFAI can be filled in by the older person him/herself or his/her carer or if this is no longer possible, also by lower skilled caregivers. Hence, the CFAI is an easy to use frailty assessment instrument. However, the fact that, until now, no cutoffs were available was seen as a disadvantage. Therefore, the present study focuses on the development of these cut-offs in order to enhance the usability of the instrument.

In response to this, the cut-off of the total score and the sub-domain scores of the CFAI are determined using a two-step cluster analysis. The mean advantage of using this method is the fact that it searches for existing groups within the data. As a consequence, the cut-offs are not set using clinical judgement or counting deficits. Based on these analyses, the total frailty score and it's subdomains are classified into 3 groups: no –low, mild and high frailty. Afterwards, construct validity was assessed.

Our analyses show that, using the developed cut-offs, frailty is associated with advanced ageing, thereby confirming earlier results from other scholars [14,39,41,50]. Regarding gender, women are often associated with higher levels of frailty [11,39,42,43,50]. By implementing our cut-offs for the total score of the CFAI and the score of the subdomains, our findings are in line with these results. Other socio-demographic indicators which are often associated with frailty are income and educational level. The less income one has [44,50-52] or the lower the educational level [44], the higher the chance of becoming frail. For the educational level, our results are in line with these findings. However, we found some inconsistency with respect to income. Although we found the lowest prevalence of high overall frailty in the highest income group (15.4%), the highest prevalence of high frailty was found in one of the intermediate income groups (41.8%). Probably the way income is measured and categorized differs between our study and the four mentioned studies. Nevertheless, generally the lower the income, the greater the odds of being in the high frailty group are.

In practice, by using the cut-offs as developed in this study, the CFAI can be used to rapidly detect and classify frail older people into "non to low frail, mid frail and highly frail" for the total frailty score and the sub-domains.

This study has some strengths and limitations. A first strength is that the large sample size allows to explore frailty profiles on a quasi-population level. Next, the robustness and the external validity of the instrument [26] has been demonstrated. Third, due to the fact that the CFAI comprises four domains with equal weights given to each domain, our results are encouraging and pointing towards a possible new way of approaching frailty, namely as a multidimensional and complex concept. Besides these strengths, some limitations must be considered. A first shortcoming might be that the sample only contained Dutch-speaking Belgians. Repeating this study by including international samples would enrich the external validity of the CFAI. Next, only community dwelling older people without cognitive impairment were invited to participate in the study. Furthermore, the external validity of the instrument and it's cut-offs should be reinforced testing the predictivity for negative outcomes like hospitalization, institutionalization, decreasing autonomy or death, using a longitudinal study.

Only be determined using the total score of the CFAI and the physical sub-domain as, to the best of our notion, research regarding these other domains in frailty, is scarce.

Implications and Directions for Further Research

This study provides support for the use of the CFAI in order to detect community dwelling older people. To obtain more insight into frailty-related problems, future research should focus on individual and contextual determinants of older people in the low, middle and high frail groups in both the total score as for the sub-domains and investigate their needs and experiences. Second, research could also focus on the predictive power and usefulness of specific profiles of frailty for identifying groups at risk for adverse outcomes such as institutionalization or mortality. For instance, an individual can by frail on one, two, three or all four domains, which will enable tailor measured preventative intervention. Finally, future studies could also focus on the dynamic aspect of frailty and develop a dynamic model of frailty, a frailty balance model. This study would be in line with [53] who found that older people could be frail without feeling frail, pointing to assets older people have in order to cope with frailty. In this respect not only deficits should be taken into account but also relevant resources older individuals may have which are often ignored in frailty research. The development of such a frailty balance model could clarify the complex relationships interplay within deficits and resources as well as complex relationships between resources and deficits.

Competing Interest

The authors declare they have no competing interest.

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