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NEPHROLOGY - ORIGINAL PAPER

Epidemiology of falls and fall-related injuries among middle-aged adults with kidney disease

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Abstract

Purpose Comorbidities, such as kidney disease (CKD), increase the likelihood of falls and fall-related injuries. Despite the focus of most research in this population on older adults, falls are a significant cause of injury throughout adulthood. Therefore, we aimed to describe the epidemiology of falls in middle-aged adults with kidney diseases.

Methods We analyzed falls and fall-related injuries among middle-aged adults (45–65 years old) with and without CKD included in the 2014 Behavioral Risk Factor Surveillance System (BRFSS) utilizing multivariate logistic regression and complex sample survey data analysis procedures.

Results Middle-aged adults with CKD were more likely to suffer a fall (2.30, 95% CI 2.07–2.55) and a fall-related injury (1.54, 95% CI 1.32–1.80) compared to those without CKD. However, only the increased likelihood for falls remained significant after correction for multiple demographic, health, lifestyle, and comorbid conditions (AOR 1.22, 95% CI 1.08–1.39). Among adults with CKD, general health status, smoking, and total comorbidity scores were significant predictors of falls and fall-related injuries ($p < 0.05$ for all). Furthermore, individual comorbidities such as COPD, asthma, depressive disorders, stroke, and arthritis also predicted falls and fall-related injuries ($p < 0.05$ for all).

Conclusion Middle-aged adults with CKD were more likely than those without CKD to fall and suffer a fall-related injury. However, injury risk did not remain elevated after accounting for differences between groups. The presence of comorbidities, especially depressive disorders, was associated with increased odds for falls and fall-related injuries. Given the high prevalence of depression among adults with CKD, the relationship between depression and falls warrants further examination.

Keywords Falls · Injury · Kidney disease · Renal disease · Balance · Trauma

Introduction

Patients with kidney disease (CKD) have been shown to be at increased risk for falls and fall-related injuries [1, 2]. Numerous physiological changes that occur as a result of CKD such as reductions in strength [3], balance [4], gait [5], cardiovascular function [6], and vision [7] may contribute to elevated fall risk. Furthermore, changes in bone metabolism may put patients with CKD at increased risk of suffering an injury as a result of a fall. Given the high prevalence of falls and increased propensity for injury as a result of falling, there has been considerable interest in fall prevention strategies in this patient population [8–20].

The majority of this interest has focused on older adults who have advanced to end stage kidney disease (ESKD) requiring hemodialysis [9]. This is likely, in part, due to the strong relationship between increasing age and falls. However, falls are an important cause of injuries among all adults including those that have not reached old age [21]. In addition to the differences in prevalence across the lifespan, the circumstances surrounding falls and fall-related injuries also differ by age. For example, young adults are more likely than older adults to fall outside during more intense activities and as a result of a slip as compared to a trip [21, 22]. These

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differing circumstances preceding a fall may also contribute to the different types of injuries suffered by young adults (e.g. wrist or ankles) as compared to older adults (e.g. head injury) [21].

Given the differences in prevalence and circumstances surrounding falls among middle-aged adults, it is important to understand the epidemiology of falls in this unique group of patients with CKD. Understanding falls in this younger group of adults with CKD could aid in the development of targeted fall prevention programs that could be implemented in early stages of CKD. Therefore, the purpose of this study was to assess the epidemiology of falls among middle-aged adults with CKD in a well-characterized community-based national random sample of middle-age adults in the United States.

Methods

Participants and procedures

For our investigation, we utilized the 2014 Behavioral Risk Factor Surveillance System (BRFSS) data [23]. We previously utilized this same database to look the epidemiology of falls in adults over the age of 65 [2]. The BRFSS is the premier annual health and lifestyle assessment of adult Americans with data collected from national random samples of adults from all US states and for more than 100 health, lifestyle, and sociodemographic variables. The BRFSS, a cross-sectional assessment administered via telephones and sponsored by the US Centers for Disease Control (CDC), utilizes probability samples of American households with a multistage cluster design to provide a nationally representative sample of adults. Data are from all 50 American states as well as the District of Columbia and three U.S. territories with more than 400,000 interviews completed in each cycle. Each state samples adult survey participants (aged 18 and older) living in private residences. The BRFSS questionnaire consists of a core component used by all states, optional modules, and questions added by individual states [2, 23]. As we utilized publicly available de-identified data that were collected by the CDC and the study protocol was approved by the CDC IRB, no further clearance from our institutional IRB was required.

Measures

Study measures were grouped into three categories. The first set of measures was related to sociodemographic characteristics of the study population. The BRFSS assesses gender, age, race, marital status, employment status, and educational attainment via structured questions where participants are asked to select the option for each demographic variable that best describes their background characteristics (with survey items given as telephone based multiple choice questions). The next set of measures pertained to the overall health status and lifestyle risk behaviors for each participant. The BRFSS has specific questions on participants': perceptions of their general health status (with response options ranging from 'excellent' to 'poor'), whether they have any healthcare coverage (with response options 'yes' or 'no'), current smoking habits and alcohol use (based on daily and weekly use), and their height and weight (from which BMI was computed). The final set of measures for this study related to self-reported prevalence of CKD, falls and fall-related injuries, and chronic disease conditions. For each of these measures, the BRFSS has specific questions for participants where they are asked "have you ever been diagnosed by a health professional with the following chronic condition" followed by a list of various chronic diseases and with the response options 'yes' or 'no' (e.g. depression, diabetes, stroke, cancer, heart disease, just to name a few). For falls, defined as "unintentionally coming to rest on the ground or at a lower level" the BRFSS asks specifically "In the past 12 months, how many times have you fallen" (with response options ranging from 0 to 365) and "Did this fall cause an injury"(with response options 'yes' versus 'no' [2].

Data analysis

In the primary approach, we computed weighted frequency estimates (numbers and percentages) of all sociodemographic, health, and chronic disease variables for the total population and also by CKD diagnosis. Individuals were assigned a lifetime comorbidity burden score based on total number of comorbidities reported and computed by addition of number comorbidities (with a minimum score of 0 and maximum of 8). Next, we estimated the prevalence of CKD, falls, and fall-related injuries in the study population. The prevalence of falls and fall-related injuries was further stratified by gender and CKD diagnosis. In the secondary approach, we utilized multivariate logistic regression analysis to estimate the probability of falls and fall related injuries in individuals with and without CKD (with falls and fall-related injuries serving as outcome variables with binary responses: yes versus no). Finally, within the CKD population, we computed age-adjusted odds ratios (AORs with 95% confidence intervals) to estimate probability of falls and fall-related injuries in individuals with various sociodemographic and health-related characteristics (again, falls and fall-related injuries were the outcome variables). Data were weighted with the provided population weights, and sampling units, using Taylor approximation representing a best estimate of point prevalence and associations between variables in the sampled population. Weighted analysis of BRFSS accounts for unequal selection probabilities, over

sampling, and nonresponse. All analyses were conducted with STATA version 14 using complex sample survey data analysis procedures.

Results

A total of 186,208 BRFSS study participants were included in our final analyses. The majority of the participants were females (51%), 55–64 years old (58%), white (67%), married or living with a partner (66%), had more than a high school diploma (58%), and with healthcare insurance coverage (88%). A CKD diagnosis was reported by 5651 (3%) study participants. Individuals with CKD were significantly different from those without CKD based on all sociodemographic characteristics and health and lifestyle behaviors except for health access coverage, smoking, and alcohol use behavior. Individuals with CKD were significantly more likely to be obese, have chronic health conditions, and report greater lifetime comorbidity burden scores ($p < 0.05$ for all, Table 1).

More than a quarter of all study participants (27%) reported suffering a fall within the past 12 months and more than a tenth (11%) also suffered an injury from these falls (Table 2). Prevalence of falls was significantly higher in females (28%), those with CKD (45%), and females with CKD (49%) compared to their counterparts ($p < 0.05$). Similarly, prevalence of fall-related injuries was significantly higher in females (13%), those with CKD (24%), and females with CKD (27%) compared to their counterparts ($p < 0.05$, Table 2).

The probability of falls and fall-related injuries were computed among those who had CKD versus those who did not using regression analysis (Table 3). Individuals with CKD were significantly more likely to report falls (OR = 2.30, 95% CI = 2.07–2.55) and fall-related injuries (OR = 1.54, 95% CI = 1.32–1.80). Individuals with CKD were more likely to fall and suffer fall-related injuries after adjustment for all demographic characteristics. The probability of falls, but not fall-related injuries, remained higher in the CKD group even after adjusting for demographic characteristics, health and lifestyle behaviors, and chronic disease conditions (AOR = 1.22, 95% CI = 1.08–1.39).

To identify groups of individuals with higher risk of falls and fall-related injuries among CKD population, we conducted a regression analysis only for individuals with CKD (Table 4). Females (OR = 1.48), those in fair or poor health (OR = 2.45) and current smokers (OR = 1.64) had higher probability of reporting falls while those with college education were less likely to report falls (OR = 0.75). Current smokers (OR = 1.45) and those in fair or poor health (OR = 1.75) were also more likely to report fall-related injuries. History of chronic disease conditions was associated with falls and fall-related injuries for majority of the chronic disease conditions we explored. The lifetime comorbidity burden score was associated with falls and fall-related injuries (i.e. individuals with higher comorbidity burden had higher odds of reporting falls and fall-related injuries) (Table 4).

Discussion

We analyzed middle-aged non-institutionalized adults from the United States included in the 2014 BRFSS to compare the risk for falls among those with and without CKD. Similar to our previous findings in older adults with CKD [2], we found that middle-aged adults with CKD were more likely to fall than adults without CKD even after adjusting for demographics, lifestyle, and health conditions. Middle-aged adults with CKD were also at increased risk for suffering a fall-related injury, but this finding did not remain significant after adjustment for lifestyle factors or chronic conditions. Among only middle-aged adults with CKD, we identified a number of risk-factors for falls and fall-related injuries including depressive disorders, general health status, female gender, and multiple comorbid conditions.

Previous literature on falls in patients with kidney disease has focused primarily on older adults who have advanced to ESKD and are undergoing hemodialysis [9]. To our knowledge, this is the first study to demonstrate that, similar to older adults [2], middle-aged adults with self-reported CKD are at increased risk for falls and fall-related injuries. However, unlike older adults with CKD, majority of the increased propensity for fall-related injuries in middle-aged adults appears to be accounted for by related issues such as lifestyle and comorbid conditions. The differences between this observation among old and middle-aged adults may be due, in part, to the differences in circumstances surrounding falls in these groups [21]. Another potential explanation is that some of the physiological changes that increase the propensity for injuries in patients with CKD have not had sufficient time to manifest in this younger group of patients [24].

Previous analyses in older adults with CKD have found relationships between falls and many demographic factors including gender, education, and BMI [2, 9, 18]. Similar to most [2, 15, 18], but not all [17], previous findings, we found that middle-aged females were more likely than men to fall. This may represent differences in risk-factors for falls among the genders [25]. Also similar to findings in older adults, we found no relationship between BMI and falls or fall-related injuries and that high education was associated with fewer falls [2]. Future research should explore gender differences in falls among middle-aged and older adults with CKD and determine if fall-prevention programs tailored to females might reduce falls and fall-related injuries.

Table 1 Participant demographic characteristics, lifestyle behaviors, and chronic conditions

Variable	Total *N* (%)	CKD *N* (%)	No-CKD *N* (%)
Sociodemographic characteristics			
Gender*			
Male	76439 (48)	2186 (43)	73945 (49)
Female	109769 (51)	3465 (56)	100943 (51)
Age groups (years)*			
45–54	76693 (42)	1907 (34)	74564 (42)
55–64	104515 (58)	3744 (66)	100324 (58)
Race*			
White	140652 (67)	3952 (60)	136282 (67)
African–American	14865 (12)	634 (16)	14162 (12)
Other Races	7241 (5)	311 (6)	6894 (5)
Multiracial	3143 (1)	166 (1)	2961 (1)
Hispanics	11994 (13)	487 (16)	11449 (13)
Marital status*			
Married/living with a partner	115048 (66)	2965 (55)	112083 (66)
Separated/divorced	36429 (19)	1527 (27)	34902 (19)
Widowed	10032 (5)	465 (7)	9567 (5)
Never married	19030 (10)	694 (11)	18336 (10)
Employment*			
Work for wages	95457 (53)	1725 (29)	93544 (53)
Self employed	20336 (11)	351 (6)	19936 (11)
Retired	21941 (10)	846 (13)	21006 (10)
Other (unable to work, out of work, etc.)	42553 (26)	2707 (51)	39506 (25)
Education*			
High school graduate or less	61011 (42)	2285 (50)	58426 (42)
More than high school less than college	49290 (30)	1661 (30)	47485 (30)
College graduate or higher	69410 (28)	1665 (20)	67549 (28)
Health and lifestyle behaviors			
General health status*			
Excellent	31906 (17)	247 (4)	31609 (17)
Very good	59519 (31)	778 (14)	58631 (31)
Good	53504 (30)	1480 (23)	51873 (30)
Fair	24507 (15)	1731 (33)	22595 (15)
Poor	11165 (7)	1384 (25)	9615 (8)
Health access coverage	164369 (88)	5206 (89)	158585 (88)
Smoking (current)	30369 (18)	1134 (19)	29355 (18)
Heavy drinking (current)	10060 (5)	190 (4)	9850 (6)
BMI (proportion of obese individuals)*	56330 (34)	2420 (45)	53687 (34)
*Disease conditions and comorbidity burden**			
Diabetes (ever diagnosed)	24054 (14)	2130 (39)	21739 (13)
Asthma (ever diagnosed)	24092 (13)	1359 (23)	22733 (13)
Depressive disorder (ever diagnosed)	40186 (21)	2520 (43)	37431 (20)
COPD/CB/emphysema (ever diagnosed)	15083 (8)	1213 (19)	13749 (8)
Coronary/heart disease (ever diagnosed)	8831 (5)	949 (17)	7821 (4)
Cancer (ever diagnosed)	13782 (7)	988 (16)	12724 (6)
Stroke (ever diagnosed)	6120 (4)	646 (10)	5418 (3)
Arthritis (ever diagnosed)	63437 (33)	3394 (58)	59752 (32)
Lifetime comorbidity burden score			
0	73392 (44)	671 (14)	72682 (45)
1	51228 (29)	1195 (25)	49963 (29)

Table 1 (continued)

Variable	Total *N* (%)	CKD *N* (%)	No-CKD *N* (%)
≥ 2	49140 (27)	3441 (61)	45473 (26)

Table 2 Prevalence of falls and fall-related injury last year

Distribution	Falls *N* (%)	Fall-related injury *N* (%)
Total population ($n = 181,208$)	47894 (27)	19630 (11)
Differences in prevalence by gender*		
All males ($n = 76,439$)	18285 (24)	6236 (8)
All females ($n = 104,769$)	29609 (28)	13394 (13)
Difference in prevalence by CKD*		
Non-CKD population ($n = 174,888$)	45183 (26)	18169 (10)
CKD population ($n = 5651$)	2452 (45)	1326 (24)
Difference in prevalence by gender and CKD*		
Males without CKD ($n = 73,945$)	17326 (24)	5796 (8)
Males with CKD ($n = 2186$)	852 (40)	391 (18)
Females without CKD ($n = 100,943$)	27857 (28)	12373 (12)
Females with CKD ($n = 3465$)	1600 (49)	935 (27)

*Statistically significant differences observed among groups at $p < 0.05$

Table 3 Probability of falls and fall-related injuries based on CKD Diagnosis

Predictors	OR (95% CI) falls	OR (95% CI) fall-related injury
Model 1		
Compares CKD group vs. Non-CKD group	2.30 (2.07–2.55)*	1.54 (1.32–1.80)*
Model 2		
Comparison in Model 1 adjusted for demographic characteristics from Table 1	1.86 (1.67–2.07)*	1.25 (1.08–1.47)*
Model 3		
Comparison in Model 1 adjusted for health and lifestyle factors from Table 1	1.58 (1.41–1.76)*	1.16 (0.97–1.36)
Model 4		
Comparison in Model 1 adjusted for chronic conditions from Table 1	1.44 (1.27–1.57)*	1.06 (0.90–1.20)
Model 5		
Comparison in Model 1 adjusted for demographic, health, and lifestyle characteristics from Table 1	1.46 (1.29–1.62)*	1.09 (0.93–1.26)
Model 6		
Comparison in Model 1 adjusted for demographic, health/lifestyle characteristics, and chronic conditions	1.22 (1.08–1.39)*	1.01 (0.85–1.20)

The binary outcome is fall history (yes or no) or fall-related injury (yes vs. no) in the past 12 months

95% CI confidence intervals, *OR* odds of falling in CKD group compared to non-CKD group. Non-CKD group serves as a reference group

*Indicates $p < 0.05$

Lifestyle factors are also related to the risk for falls in middle-aged adults with CKD. Smoking status, a potentially modifiable risk-factor, was a predictor of both falls and fall-related injuries. There are many potential explanations for the relationship between smoking status and falls. Increased trips outside to smoke may put smokers at increased environmental risk, especially in bad weather [26]. Smoking is also associated with many comorbid conditions (such as cardiovascular disease and diabetes) and poor habits that may put adults at increased risk of suffering a fall [27]. Smoking cessation, independent of its relationship with falls, would be a positive health behavior change for patients with CKD [28]. However, an added benefit of smoking cessation may be a reduction in unintentional injuries.

Table 4 Falls and fall-related injuries in individuals with CKD ($n=5651$)

Predictors	Falls AOR (95% CI)	Fall-related injury AOR (95% CI)
Sociodemographic characteristics		
Gender		
Males	Ref	Ref
Females	1.48 (1.21–1.81)*	1.30 (0.99–1.73)
Race		
White	Ref	Ref
African–American	0.86 (.69–1.18)	0.93 (0.69–1.39)
Other races	0.83 (0.63–1.16)	0.81 (.48–1.37)
Multiracial	0.63 (0.54–1.08)	1.17 (0.67–2.07)
Hispanics	1.62 (0.75–2.70)	1.31 (0.81–3.06)
Married/Living with a partner	Ref	Ref
Widowed, separated, divorced, never married	1.23 (1.00–1.51)	1.16 (0.93–1.45)
Employment		
Work for wages	Ref	Ref
Self employed	0.89 (0.56–1.40)	1.27 (0.62–2.66)
Retired	1.20 (0.86–1.68)	1.48 (0.92–2.41)
Other (unable to work, out of work, etc.)	2.37 (1.84–3.04)*	2.57 (1.82–3.64)*
Education		
≤ High School Graduate	Ref	Ref
> High school and < college graduate	1.15 (0.91–1.44)	0.93 (0.66–1.21)
≥ College graduate	0.75 (0.59–0.93)*	0.78 (0.57–1.08)
Health and lifestyle behaviors		
General health status		
Excellent/good	Ref	Ref
Fair/poor	2.45 (1.98–3.02)*	1.75 (1.32–2.33)*
Health access coverage (yes vs. no)	0.96 (0.69–1.26)	0.89 (0.63–1.17)
Smoking (current yes vs. no)	1.64 (1.27–2.16)*	1.45 (1.06–1.93)*
Heavy drinking (current)	1.04 (0.63–1.44)	0.81 (0.63–1.26)
BMI (proportion of obese individuals)	1.08 (0.81–1.48)	1.20 (0.81–1.62)
Disease conditions and comorbidity burden		
Diabetes (yes vs. no)	1.47 (1.20–1.80)*	1.36 (1.01–1.84)
Asthma (yes vs. no)	1.75 (1.39–2.21)*	2.12 (1.58–2.87)*
Depressive disorder (yes vs. no)	2.57 (2.09–3.15)*	2.28 (1.72–3.03)*
COPD/CB/emphysema (yes vs. no)	1.87 (1.48–2.36)*	1.72 (1.26–2.33)*
Coronary/heart disease (yes vs. no)	1.66 (1.27–2.16)*	1.76 (1.27–2.44)*
Cancer (yes vs. no)	1.27 (0.99–1.72)	1.37 (0.93–2.03)
Stroke (yes vs. no)	2.01 (1.45–2.80)*	1.54 (1.12–2.34)*
Arthritis (yes vs. no)	2.30 (1.85–2.84)*	2.14 (1.58–2.90)*
Lifetime comorbidity burden score		
0	Ref	Ref
1	1.54 (1.11–2.13)*	1.44 (0.96–2.01)
≥2	2.97 (2.10–4.21)*	3.63 (2.09–6.31)*

AOR adjusted odds ratios (adjustments made for age). The outcome is falls and fall-related injuries in the past 12 months (yes vs. no)

$p<0.01$

Comorbid conditions, as well as the total comorbid burden, were among the strongest predictors of falls and fall-related injuries. Comorbidity burden may also contribute to differences in falls attributed to general health status. In older adults with CKD, previous studies have identified comorbidities such as diabetes, cancer, and arthritis to

be associated with falls [2, 8]. In addition to these previously identified risk factors, we have also identified COPD, asthma, and coronary heart disease as risk factors for falls and fall-related injuries in middle-aged adults with CKD. This is similar to observations in other populations such as the aged where these conditions are also associated with falls [29]. Comorbid conditions may increase falls in many ways including physical decrements, poorer health status, and polypharmacy (i.e. usage of multiple medications). Polypharmacy and physical decrements are modifiable risk factors that warrant further examination in this population [30].

Among the comorbid conditions we tested, the strongest individual risk factor for falls among middle-aged adults with CKD was a self-reported diagnosis of a depressive disorder. Previous studies have found depressive disorders and anti-depressant medications to be independently associated with increased risk of falls in the elderly [31] and in patients undergoing hemodialysis [8, 14]. To our knowledge, this is the first study to identify depressive disorders as a risk factor for falls among middle-aged patients who have not necessarily advanced to ESKD. One reason for this increased risk of falls could be the relationship between depression and gait and mobility impairments [32]. Depression is among the most frequently observed comorbidities in patients with CKD, [33] and given this high prevalence is an important factor that should be explored in fall prevention programs.

The results of this study have broader implications for clinical practice and public health [8, 9, 13, 14]. First, given the numerous variables examined and the complex interactions between these variables and falls in individuals with CKD, clinicians should consider adopting a multifactorial approach to screening for fall risk in middle-aged adults. Second, clinicians should consider targeting risk factors for preventive and therapeutic action among high-risk groups of individuals with CKD. Finally, not all the variables that we included in our analyses are modifiable. Clinicians should focus on modifiable and extrinsic factors to prevent falls (e.g. home safety, medication monitoring, and depression treatment) as opposed to non-modifiable and intrinsic risk factors (e.g. age, gender, and history of falls). Education of individuals with CKD about the risk of falls and explanation of various components of fall prevention practice should improve compliance, which in turn should lead to better overall health outcomes for middle age adults with CKD [8–14].

This study has several limitations. The current study is cross-sectional which limits our ability to determine cause-and-effect relationships between variables. BRFSS is also retrospective and relies on recall which can be prone to recall bias [34], social desirability, and under- or over-estimation of some health-related variables. CKD is a complex disease and BRFSS does not allow for us to differentiate between cause and stage of kidney disease. Furthermore, people with CKD may not be available to answer questionnaires like BRFSS due to hospitalizations, appointments, or other limitations. This may limit the generalizability of the current examination. Despite these limitations, this study has many strengths. To our knowledge, this is the first study to examine risk factors for falls and fall-related injuries among a large national sample of middle-aged adults with CKD in the United States.

In conclusion, we found that middle-aged adults with CKD are at increased risk of falling and for suffering a fall-related injury. However, unlike older adults, majority of the higher risk of fall-related injury in middle-aged adults with CKD was associated with differences in demographic, lifestyle, and comorbid conditions. Among only patients with CKD, overall comorbidity burden, as well as asthma, COPD, heart disease, stroke, and arthritis were all associated with falls and fall-related injuries. However, the highest individual risk factor associated with both falls and fall-related injuries was a previous diagnosis of a depressive disorder. Given the high prevalence of depression in patients with CKD, depression may be an appropriate risk factor to target for early prevention of falls and related injuries.

Compliance with ethical standards

Ethical standards This study involved de-identified and publically available secondary data. However, all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest BMK is a consultant for the Academy of Nutrition and Dietetics. JK, KW, and MW declare no conflicts of interest. JS has received funding from the National MS society, National Institutes of Health, Permobile, Inc., and Johnson & Johnson, Inc. JS has consulted for AbbVie and is the owner of Sosnoff Technologies, Inc.

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