

## Incidence and characteristics of falls leading to hip fracture in Iranian population

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### Abstract

An estimated one in three adults aged 65 years or older falls each year, making falls a major health concern. Hip fractures are the most serious consequences of falls in elderly people. Identifying the characteristics of falls leading to hip fracture may provide information about high risk individuals, environment, and activities useful for the development of intervention strategies. Little is known, however, about the incidence and characteristics of falls leading to hip fracture in Middle Eastern countries. Therefore, the authors presented data from the Iranian Multicenter Study on Accidental Injuries, a prospective population-based study conducted in 9 provinces of Iran in 2003. All the hospitals serving about 9.5 million people in the study area were prospectively surveyed for any incident injury resulting from accidental events. A total of 2186 patients (1372 male, 814 female) were admitted due to any injurious fall events, where 572 (26.2%) of them suffered a hip fracture. Annual incidence rates of injurious fall events and related hip fractures were 116.3 and 30.4 per 100,000 person-years, respectively. These figures were 237.1 and 93.6 per 100,000 person-years for people over the age of 50 years, respectively. 71% of fall injuries and 76% of hip fractures occurred indoors. Among 450 patients with hip fractures  $\geq 50$  years of age, 61.8% arose from a fall from standing height or less. Only 1 in these 450 hip fractures occurred at the time of recreational activity. In multivariate logistic regression analysis, no factor was an independent predictor of hip fractures comparing to other fall-related injuries among younger participants ( $\geq 20$  and  $< 50$  years). For older patients, falls from standing height or loss (odds ratio (OR) = 2.67), falls during walking (OR = 1.71), and falls on stairs (OR = 1.73) were detected as risk factors of hip fracture. Married persons and those falling from a ladder or other elevations were less likely to fracture their hip in this age group. Our data suggest that modification of the factors external to the homes is less likely to prevent more than a small proportion of fall-related hip fractures in Iran. Further studies on this topic have potential applications for developing preventive strategies.

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### Introduction

Falls are a major health problem among the elderly. Thirty percent of community-dwelling persons over the age of 65 fall each year [1,2], and the rate increases to 40% among those over the age of 80 [3]. These events among older persons are the result of many pathophysiologic and aging processes, as well as possible behavioral, pharmacologic, and environmental factors [4]. Injuries resulting from falls place a tremendous burden on

both the injured older person and the health care system. In addition, a fall in an older person, even without injury, may produce fear, a decrease in mobility and activity, or a change in the quality of life [5].

Hip fracture is considered the most important osteoporosis-related condition in terms of morbidity, mortality, and cost [6]. More than 90% of hip fractures among older people are reported to be associated with a fall [7,8]. Effective preventive strategies require a better understanding of the characteristics of injurious falls leading to hip fractures among elderly persons. In addition, there may be different patterns for fall injuries in different communities [9]. For instance, persons residing in urban areas

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of China have lower probability of falls and fall-induced hip fractures comparing to Western societies [10], which may point to some potential culture-specific protective factors against these events. Within the context of the Iranian Multicenter Study on Accidental Injuries (IMSAI), a large-scale population-based prospective study aimed at classifying and quantifying burden of unintentional injuries in Iran, information was sought that would enable us to describe the characteristics of injurious falls leading to hip fractures among younger and older Iranian people.

**Materials and methods**

The IMSAI study was conducted by the Ministry of Health and Medical Education with collaboration of 13 medical universities and schools across the country [11]. All public hospitals in 65 cities from 9 provinces were enrolled in the study. Duration of the study was 135 days (4.5 months) in all centers, beginning on a date between 15 June and 15 July 2003 in each center.

The main study was designed to record any incident injury resulting from unintentional accidents and to evaluate circumstances and outcomes of that event. 260 interviewers were trained for this purpose, and 10 different standardized questionnaires were developed considering different possible accidents (such as traffic accidents, fires, falls, poisoning, drowning, etc) and outcomes classified in the Global Burden of Disease Project of World Health Organization [12]. Results of completed fall questionnaires were considered for this study. A fall was defined as an unexpected event where a person falls to the ground from an upper level or the same level [13].

The detailed methods of the IMSAI study have been outlined elsewhere [11]. The interviewers systematically searched emergency, surgery, and orthopedic wards of all hospitals in the study area in a daily basis. Any new patient admitted with a potential accident-related etiology was asked to provide further information about the accident and entered the study if he or she met the definition of the particular accident. To enhance quality of data gathering and prevent under-ascertainment of cases or duplicate recording, a quality control committee systematically and unpredictably searched all the sites and evaluated performance of the interviewers in different areas. Patients or their proxies completed the interviewer-administered standardized questionnaire related to the event. For the fall questionnaire, 65% of patients answered the interviewers themselves and first-degree relatives were the respondents for 32% of cases. 3% of questionnaires were answered by proxies present at the time of accident. The interviewer sought information on demographic and residential status, time of the event, location of the fall, height and level of the fall, and activity in the time of the event. Medical diagnosis was derived from the patient files and verified with the corresponding nurse or physician. All the cases with radiographically confirmed proximal femur fractures were included as hip fractures.

At the end of the study, a thorough data exploration was performed by database designers to ensure that the same patient was counted only once. For each province involved in the study, the population estimate for mid-summer of 2003 was obtained from the Iran Statistical Yearbook [14]. These data were

projected from the last national census and classified for different genders and age groups. The age- and sex-specific annual incidence rates of overall fall accidents and related hip fractures, per 100,000 person-years, were calculated for the study population. We multiplied each incidence rate by 2.7 to get the annual rates (given 365 days of a year divided by 135 days of the study period). The 95% confidence intervals (95% CI) for the age- and sex-specific rates were calculated assuming a Poisson distribution.

Considering potentially different pattern of falls leading to hip fracture in childhood and adolescence, fallers <20 years of age were excluded from the analyses. To assess the independent relationship between different fall characteristics and hip fracture occurrence among injured fallers, multivariate logistic regression analysis was used. The odds ratio (OR) of hip fracture for different variables and their corresponding 95% confidence intervals (95% CI) were retrieved. Excessive collinearity between independent variables was first ruled out by calculation of variance inflation factor (VIF) for different models [15]. Goodness of fit was evaluated using the Hosmer–Lemeshow statistic. Considering possible differences between older and younger participants regarding their contributing factors to hip fractures, we performed analyses in two subgroups with the age cutoff of 50 years. Statistical analyses were performed using Intercooled STATA package (Version 8, Stata Inc., College Station, TX, USA).

**Results**

In summary, 2186 patients were admitted due to any injurious fall event, of whom 572 suffered a hip fracture. 1372 male (mean age 46.7 ± 20.7 years) and 814 female (mean age 58.7 ± 19.1 years) composed the original population of fallers, while hip fracture sufferers were 304 male (mean age 59.9 ± 20.7 years) and 268 female patients (mean age 70.2 ± 15.3 years). 63% of injured fallers and 60% of hip fracture sufferers lived in urban areas. 68% of injured fallers and 63% of hip fracture sufferers were married.

The age- and sex-specific incidence rates for overall documented fall events and hip fractures are presented in Tables 1 and 2, respectively. The crude annual incidences of injurious fall events and related hip fractures were 116.3 and 30.4 per 100,000 person-years, respectively. These figures for people over the age of 50 years were 237.1 and 93.6 per 100,000 person-years, respectively.

As illustrated in Fig. 1, rate of overall fall injuries and fall-related hip fractures increased exponentially with age. This increment was more significant in the seventh and eighth decades of life. As shown in Fig. 2, most of hip fractures in the elderly men occurred in the late morning or early night

Table 1  
Age- and sex-specific incidence rates (per 100,000 person-year) of injurious fall events coming to acute medical attention; Iranian Multicenter Study on Accidental Injuries, 2003

Age	Male				Female				F:M ratio
	No.	Population	Rate	95% CI	No.	Population	Rate	95% CI	
20–29	379	860,377	118.9	114.5–123.4	78	836,162	25.2	23.1–27.3	0.2
30–39	224	602,904	100.3	95.4–105.2	78	584,690	36.0	33.1–39.0	0.4
40–49	195	452,868	116.3	110.2–122.3	92	438,767	56.6	52.3–60.9	0.5
50–59	145	240,765	162.6	152.8–172.4	110	260,201	114.1	106.2–122.0	0.7
60–69	128	241,465	143.1	133.9–152.3	147	208,653	190.2	178.8–201.6	1.3
70–79	181	145,143	336.7	318.51–354.9	200	129,559	416.8	395.4–438.2	1.2
≥80	120	38,192	848.3	792.2–904.5	109	34,432	854.7	795.4–914.1	1.0
Total	1372	2,581,714	143.5	140.7–146.3	814	2,492,464	88.2	85.9–90.4	0.6

Table 2  
Age- and sex-specific incidence rates (per 100,000 person-year) of fall-related hip fracture; Iranian Multicenter Study on Accidental Injuries, 2003

Age	Male			Female			F:M ratio
	No.	Rate	95% CI	No.	Rate	95% CI	
20–29	37	11.6	10.2–13.0	6	1.9	1.4–2.5	0.2
30–39	29	13.0	11.2–14.7	12	5.5	4.4–6.7	0.4
40–49	30	17.9	15.5–20.3	8	4.9	3.7–6.2	0.3
50–59	30	33.6	29.2–38.1	15	15.6	12.6–18.5	0.5
60–69	34	38.0	33.3–42.8	52	67.3	60.5–74.1	1.8
70–79	73	135.8	124.3–147.3	103	214.7	199.3–230.0	1.6
≥80	71	501.9	458.7–545.1	72	564.6	516.3–612.8	1.1
Total	304	31.8	30.5–33.1	268	29.0	27.8–30.3	0.9

hours. Hip fractures in the elderly women showed three peak times in early morning (around 5 to 6 AM), late morning, and late evening. Characteristics of injurious fall events leading to hip fractures are compared with those of other injuries in Table 3. Among men and women  $\geq 20$  and  $< 50$  years of age, most falls leading to hip fractures occurred at indoor places, from a higher level of height and during a working activity. Men in this group were more likely to fall and fracture their hip in their working places or offices, while most of falls and fractures in women occurred at homes. For those  $\geq 50$  years, hip fractures mostly occurred with falls from standing levels and during walks. In the older group, 84.7% of women and 73.1% of men fractured their hips in indoor places. Only one patient in this group experienced his fracture during sport activity.

Results of the multivariate regression analysis are presented in Table 4. Among younger participants ( $\geq 20$  and  $< 50$  years), no factor was an independent predictor of hip fractures comparing to other fall-related injuries. For older patients, married persons and those falling from a ladder or other elevations were less likely to fracture their hip. Although not reached to statistical significance, male gender was almost a protective factor among those over 50. Falls from standing height or loss (odds ratio [OR] = 2.67), falls during walking (OR = 1.71), and falls on stairs (OR = 1.73) were detected as risk factors of hip fracture in the older group.

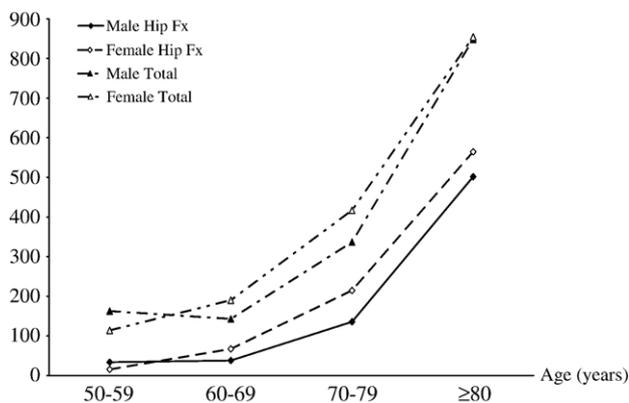


Fig. 1. Age trends for overall fall events and hip fractures in different genders.

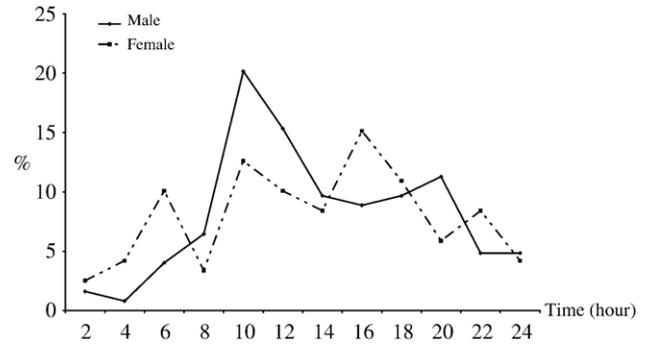


Fig. 2. A 24-h distribution of fall-related hip fractures in the study population aged  $\geq 50$ .

## Discussion

This is the first study in Iran reporting incidence and characteristics of fall-related hip fractures. Given the relatively low bone mineral density [16] and the extreme prevalence of vitamin D deficiency in Iran [17,18], one would expect high incidence rate of fractures among Iranian population. However, fracture rates of about 94 per 100,000 person-years for the senior subgroup of Iranian people are noticeably lower than the rates observed in Western populations [19–21] and even in Asian [22] and Middle Eastern countries [23]. Inspections for potential factors attributable to observation of such low rates are warranted. Circumstances around falls leading to hip fractures are one of these factors.

The age-related decrease in bone mass and increase in fall frequency appear to account for some, but not all, of the increase in hip fracture incidence rates with age [24,25]. Characteristics of the fall are proposed as important key factors contributing to hip fracture risk [26]. Our findings are consistent with several other studies describing these characteristics [1,3,5,25,27–31]; however, there seems to be some differences between Iranians and other populations leading to lower incidence rates in our population.

The distribution pattern for place of falls in our study is rather different from other studies, reflecting mainly the characteristics of Iranian lifestyle. Although like other studies the majority of hip fractures occurred indoors and at home, the relative frequency of these events was higher than similar population-based studies in Western countries [25,27–29]. This could be explained by the fact that most of our elderly people spend most of their time in their residences and do not engage in social or recreational activities. This could also be understood from the activity during falls, in which we detected just one hip fracture induced in the course of sport or entertaining activity for older people. Moreover, the significantly lower percentage of young women with fractured hip in the working place reflects the nationwide occupational pattern, in which most of Iranian women do not have an official job outside their homes. This suggests that modification of the environmental factors external to the residences is less likely to prevent more than a small proportion of osteoporotic hip fractures in Iran.

Table 3  
Circumstances around falls leading to hip fractures and comparison with other injurious falls<sup>a</sup>

	Men				Women			
	≥20 and <50 years		≥50 years		≥20 and <50 years		≥50 years	
	Hip Fx	Other injuries	Hip Fx	Other injuries	Hip Fx	Other injuries	Hip Fx	Other injuries
<i>Place of fall</i>								
Home	28 (29.3)	231 (32.9)	132 (63.5)	168 (45.9)	21 (80.8)	170 (77.3)	195 (80.6)	168 (52.8)
Work–place/office	41 (42.7)	319 (45.4)	26 (12.5)	118 (32.3)	1 (3.8)	12 (5.5)	11 (4.5)	118 (36.4)
Passage (streets/alleyways)	9 (9.4)	59 (8.4)	29 (13.9)	43 (11.7)	3 (11.5)	25 (11.4)	29 (12.0)	43 (13.4)
Recreative places (parks/sport clubs/mountains)	15 (15.6)	88 (12.5)	17 (8.2)	32 (8.7)	1 (3.8)	13 (5.9)	3 (1.2)	33 (9.9)
Unknown	3 (3.1)	5 (0.7)	4 (1.9)	5 (1.4)	0 (0)	2 (0.9)	4 (1.7)	5 (1.5)
<i>Condition</i>								
Indoors	57 (59.4)	442 (63.0)	152 (73.1)	257 (70.2)	22 (84.6)	180 (81.1)	205 (84.7)	264 (81.5)
Outdoors	36 (37.5)	255 (36.3)	52 (25.0)	104 (28.4)	4 (15.4)	40 (18.0)	33 (13.6)	55 (17)
Unknown	3 (3.1)	5 (0.7)	4 (1.9)	5 (1.4)	0 (0)	2 (0.9)	4 (1.7)	5 (1.5)
<i>Height of fall</i>								
>Standing	75 (78.1)	519 (73.9)	91 (43.8)	249 (68)	16 (61.5)	160 (72.1)	73 (30.2)	176 (54.3)
Standing	16 (16.7)	166 (23.6)	109 (52.4)	107 (29.2)	10 (38.5)	58 (26.1)	154 (63.6)	141 (43.5)
<Standing	2 (2.1)	12 (1.7)	4 (1.9)	5 (1.4)	0 (0)	2 (0.9)	11 (4.5)	2 (0.7)
Unknown	3 (3.1)	5 (0.7)	4 (1.9)	5 (1.4)	0 (0)	2 (0.9)	4 (1.7)	5 (1.5)
<i>Activity during fall</i>								
Walking	27 (28.1)	159 (22.6)	142 (68.3)	149 (40.7)	14 (53.8)	122 (55.0)	196 (81.0)	245 (75.6)
Sitting/lying down	1 (1.0)	17 (2.4)	6 (2.9)	14 (3.8)	0 (0)	4 (1.8)	11 (4.5)	5 (1.5)
Working activity	55 (57.3)	453 (64.5)	59 (28.4)	199 (54.4)	19 (34.6)	76 (34.2)	35 (14.5)	71 (22)
Recreation (sports/entertainment)	13 (13.5)	73 (10.4)	1 (0.5)	4 (1.1)	3 (11.5)	20 (9.0)	0 (0)	3 (0.9)
On stairs/steps	12 (12.5)	95 (13.5)	38 (18.2)	51 (13.9)	8 (30.8)	87 (39.2)	54 (22.3)	84 (25.9)
From ladder/Scaffolding	43 (44.8)	311 (44.3)	36 (17.3)	147 (40.2)	3 (11.5)	43 (19.4)	12 (4.9)	38 (11.7)

<sup>a</sup> Data are presented as frequency (percentage in parentheses).

Until the age of 60, fall injuries and hip fractures in our study population were considerably more incident in men. After this age, however, the rates showed a dramatic shift in favor of increased incidence in women. Like the present findings, other community-based surveys have often shown that older women fall more often than men [1,2,5]. Increased incidence of falls among older women has been attributed to their poorer functional abilities in some studies [2,32,33].

Most of our elderly patients were walking at the time of hip fracture. Although level of fall more than standing height was more prevalent in younger patients, this pattern reversed in older people. This is in agreement with other studies which observed majority of hip fractures resulting from falls from standing height or less in the elderly [27–29].

As shown in Table 3, women are more prone to fall on stairs or steps. Especially from preventive aspects, stairs are important factors related to the fall events as 10% of fall-related deaths are estimated to occur as a consequence of stair-related falls [34]. In our study, falls in stairways contributed to 19% of hip fractures among the elderly. Although the observed relative frequency of stair-related hip fractures in this study is considerable per se [27,35], the figures may be much higher in urban areas as our study population included rural and semi-rural areas as well (considering that stairway structures are not part of routine rural residences in Iran).

An interesting finding of this study was the time pattern of hip fractures. As in our case, other studies have found that the majority of falls among home-dwelling elderly persons commonly take place during periods of maximal activity [2,31]. The occurrence of two peak fracture hours before noon and in the evening has been explained by the increased activity of meal preparation [36]. However, we detected another incidence peak in the early morning hours, especially for elderly women. This finding, although could be induced merely by chance, seems to be linked to the ritual customs of our population. Islam is the mostly practiced religion across our

Table 4  
Odds ratio of hip fracture occurrence for different risk factors in younger and older participants based on multivariate logistic regression analysis

	≥20 and <50 years		≥50 years	
	years		years	
	Odds ratio	95% CI	Odds ratio	95% CI
Male gender (vs. female)	0.86	0.51–1.46	0.78	0.59–1.05
Urban residence (vs. rural)	1.28	0.85–1.92	1.07	0.82–1.39
Married (vs. single or widowed)	0.56	0.15–2.02	0.61*	0.45–0.83
Falling at home (vs. other places)	0.93	0.53–1.62	1.70	1.06–2.74
Indoor falling (vs. outdoor)	0.99	0.58–1.70	1.14	0.71–1.81
Standing or less height of fall (vs. over standing)	0.78	0.16–3.69	2.67*	1.03–6.90
Walking during fall (vs. other activities)	1.38	0.85–2.23	1.71*	1.23–2.38
Falling on stairs (vs. none)	0.83	0.46–1.49	1.73*	1.25–2.37
Falling from ladder (vs. none)	1.04	0.64–1.67	0.47*	0.30–0.71

\* Significant at 0.05 level.

country, and one of its highly recommended instructions is doing regular prayers five times daily. The first of these prayers should be in early morning before the dawn. Although this study was not able to directly assess this potential situational risk factor, it is probable that senior individuals who commit this rite regularly are at greater risk for fall and fall-induced hip fractures. The main reasons for this association could be the sleepy individuals and the gloomy environment [27].

Another important potential factor altering predisposition to falls in Iranian population is the Iranian carpet. Virtually in all Iranian houses the majority of passageways are covered with some kind of carpet. This feature of Iranian life could have some positive effects for two distinguished risk factors of falls. Carpets could reduce rate of slipping on slick surfaces common in Western houses [27,28], and, in some circumstances, they can absorb part of the fall energy and reduce the direct impact of hard landing surfaces [9]. However, carpet can also be considered a potential risk factor for falls as uneven corners present a tripping hazard for the elderly and may increase the risk of falls. These potential roles are not verified in this study and need further valid studies.

Regression analysis showed several factors related to hip fractures in over 50-year-old patients. Marriage (comparing to being single, widowed, or divorced) was a protective factor against hip fracture in this group, suggesting a role for social and family support in prevention of hip fractures. Falls from stairs or during walking were observed to be independent predictors of fracture among this population, as suggested by other studies [27–29]. However, the observation of reduced risk of hip fracture among fallers from ladders runs contrary to expectation. An explanation for this finding could be that this factor is related to health status of our elderly people. In other words, that fraction of the older population who utilize ladders are in better health condition comparing to others. The great proportion of our elderly population who are not engaged in recreational and outdoor physical activities are less likely to use ladders due to age-related precautions. This hypothesis, however, needs validation in future studies.

The main limitation of this study was its shortcomings in the ability to describe all the clinically important characteristics of the falls leading to hip fractures. IMSAI study was designed to portray the main characteristics of falls leading to any sort of burden in Iranian population. These characteristics included the timing of the fall, the place and location of the event, and the subject activity during the fall. A variety of other risk factors, however, are suggested to play a role in falls leading to hip fractures. A brief list of these factors includes poor vision, low cognitive status, medications, co-morbidities, fall direction, high energy of the fall, and hard landing surface [1,3,9,25,27,28]. Despite the extent and comprehensiveness of the study, we did not capture these risks. However, in the case of risk factors reported in this study, generalization of the results to Iranian population seems highly acceptable.

Another limitation was the duration of this study. Some previous studies [34,37,38], but not all [27,39], have reported seasonal variations in the incidence of fall-related hip fractures. Facing up to this potential bias, most studies aimed at reporting

annual incidence rates for hip fractures observe their target populations for at least one complete year. Our country has a greatly variable climate with sub-zero winters in most of the provinces. As this study was conducted in the warm season of the year, we could not rule out the possibility of underestimation of annual incidences in overall fall events and resultant hip fractures. The main reason for short duration of the IMSAI study was the magnitude of the project and the size of study population. All the hospitals serving more than 9.5 million persons were enrolled in this study, and, given the extensive expenses and various difficulties regarding quality control of the study, we were compelled to shorten the study period [11]. Further studies to evaluate impact of seasonal variation on hip fracture rates among Iranian population are needed.

The results of this study should be treated cautiously regarding incidence of falls as our rate estimates reflect the number of falls leading to hospital admission in our study area. Comparing to one similar study from the USA, Iranian rates of falls coming to acute medical attention are lower [5]. However, this measure could be very variable considering the economic and cultural differences between societies and availability of medical services to the population. In several prospective studies of community-dwelling elderly, approximately 10% of falls are found to result in injuries requiring medical attention and 3 to 5% in a fracture [9,34]. However, it is globally accepted that virtually all the cases with hip fracture will seek medical attention [6]. As the results of quality control group showed satisfactory ascertainment rates in all study centers, we believe that, although there is a room for underestimation of fall-related injuries in our large-scale study, our findings especially regarding the incidence of hip fractures are reliable.

In summary, we found a relatively low incidence of fall-related hip fracture in Iran. These findings disagree with our expectations considering the bone mineral density and vitamin D status of Iranian population [16–18]. This finding could be the result of several potential environmental factors, which circumstances around falls could be one of them. Further studies are needed to evaluate these factors and their potential application in future preventive programs.

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