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Systematic Review

Sociodemographic and Lifestyle Risk Factors Associated with Fragility Hip Fractures: A Systematic Review and Meta-Analysis

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Citation: Yeritsyan, D.; Momenzadeh, K.; Mohamadi, A.; Mortensen, S.J.; Beeram, I.R.; Caro, D.; Kheir, N.; McNichol, M.; Wixted, J.J.; Appleton, P.; et al. Sociodemographic and Lifestyle Risk Factors Associated with Fragility Hip Fractures: A Systematic Review and Meta-Analysis. *Osteology* **2024**, *4*, 64–87. https://doi.org/10.3390/osteology4020006

Academic Editor: Georg Osterhoff

Received: 18 January 2024
Revised: 14 March 2024
Accepted: 6 May 2024
Published: 14 May 2024

Abstract: Hip fractures inflict heightened morbidity and mortality upon older adults. Although previous studies have explored the impact of individual demographic factors on hip fracture risk, a comprehensive review can help reconcile disparities among these factors. This meta-analysis encompassed 69 studies involving 976,677 participants and 99,298 cases of hip fractures. We found that age $\geq$ 85 (OR = 1.75), BMI < 18.5 (OR 1.72), female sex (OR = 1.23), history of falls (OR = 1.88), previous fractures (OR = 3.16), menopause (OR 7.21), history of maternal hip fractures (OR = 1.61), single and unmarried status (OR = 1.70), divorced status (OR 1.38), residing in a residential care facility (OR = 5.30), and living alone (OR = 1.47) were significantly associated with an increased incidence of hip fracture. Conversely, BMI ranging from 25 to 30 (OR = 0.59), BMI > 30 (OR = 0.38), parity (OR = 0.79), non-Caucasian descent (overall OR = 0.4, Asian OR 0.36, Black OR = 0.39, and Hispanic OR = 0.45), and rural residence (OR = 0.95) were significantly associated with a diminished risk of hip fracture. Hip fracture patients exhibited significantly lower weight and BMI than the non-fracture group, while their age was significantly higher. However, age at menopause and height did not significantly differ between the two groups.

Keywords: sociodemographic; lifestyle; risk factor; hip fracture; fragility fracture

1. Introduction

Hip fractures are particularly concerning injuries since they cause considerable pain and loss of function and increase morbidity and mortality in the individual affected [1,2]. Elevated hip fracture rates are most often observed in older adults; a demographic group expected to increase in numbers significantly in the coming years [3]. Consequently, the

associated rise in hip fracture rates will pose an amplified burden on healthcare systems as the population ages. For this reason, a renewed focus has been placed on determining the risk factors predisposing individuals to this injury [3–5].

Further, risk assessment scales have been developed to identify patients at greater risk of experiencing hip fractures. Historically, such strategies have primarily focused on bone mineral density (BMD) as measured by dual-energy X-ray absorptiometry (DXA). Although BMD is an essential element of a patient's fracture risk profile, many demographic factors are reliable predictors of hip fracture [6]. The 10-year fracture risk assessment tool (FRAX) considers some factors, including age, weight, sex, family history, and previous fracture, in its calculation [7]. However, recent studies have shown strong links between hip fractures and other demographic factors not traditionally included in risk assessments. These include, but are not limited to, environmental factors and marital status [3,8]. While a recent systematic review and meta-analysis by Mortenson et al. sheds light on modifiable risk factors for hip fractures and provides valuable insights into factors such as weight, BMI, coffee and alcohol consumption, and smoking habits, it also highlights that existing research may not fully encompass all relevant sociodemographic factors [9].

Many studies have reported individual demographic factors impacting hip fracture risk assessment, but a comprehensive review may be appropriate. Our study brings new insights into the field by comprehensively assessing hip fracture risk factors. It includes well-known risk factors and under-researched sociodemographic and lifestyle elements, which current tools such as FRAX do not cover comprehensively. Therefore, this systematic review and meta-analysis study aims to integrate recent developments to provide a better consensus regarding sociodemographic and lifestyle risk factors for hip fracture.

2. Materials and Methods

2.1. Search Strategy and Selection Criteria

Following the published guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) group, we searched EMBASE, PubMed Publisher, Web of Science™, Cochrane Central, and clinicaltrials.gov in September 2017. An updated search was performed in January 2022 to add all studies to date. The following keywords were used in the search: "hip", "hips", "fracture", "osteoporosis", "osteoporo", "fragility fracture", "risk", "odds ratio", and "hazard ratio" (see Appendix A, Search strategy). Furthermore, references to relevant studies were used in the search process. We included studies reporting demographic risk factors for osteoporotic hip fractures. Studies were eligible for inclusion if they met the following criteria: (1) inclusion of adult patients with osteoporotic hip fractures, (2) case-control or cohort studies, (3) full-text articles available in English, and (4) at least one year of follow-up. Meeting presentations, abstracts, reviews, case reports, and studies containing patients under eighteen were excluded from this analysis. The PICOS framework is presented in Table 1.

Table 1. PICOS framework.

Parameter	Description
Population	Includes both a healthy population and a population with hip fractures.
Intervention/Exposure	Involves examining a series of risk or protective factors associated with hip fractures.
Comparison	Compares patients with hip fractures to a healthy control population.
Outcome	Focuses on the occurrence of hip fractures as the primary outcome.
Study Design	Encompasses case–control and cohort studies.

2.2. Screening and Data Extraction

Four investigators screened studies independently for eligibility (AM, DY, SJM, and KM). After removing duplicates, we identified 14,932 studies in the first search and an additional 4040 in the updated search, of which 69 were included in the quality assessment

and data synthesis (Figure 1, Prisma flowchart). Three independent reviewers (AM, DY, and DC) utilized a standardized template to extract data, encompassing journal name, first author, publication year, span of participant enrollment, study design, country of study, number of included patients, sex ratio, mean participant age, duration of follow-up, demographic risk factors, fracture occurrences, and confounding variables adjusted for in analyses (Table 2). We carefully considered and evaluated the variables selected for this study to detect potential overlap in grouping and categorization. We assessed overlap within primary studies to ensure the inclusion of unique patient populations in the data analysis. Ultimately, the data presented by the primary papers constrain our analysis.

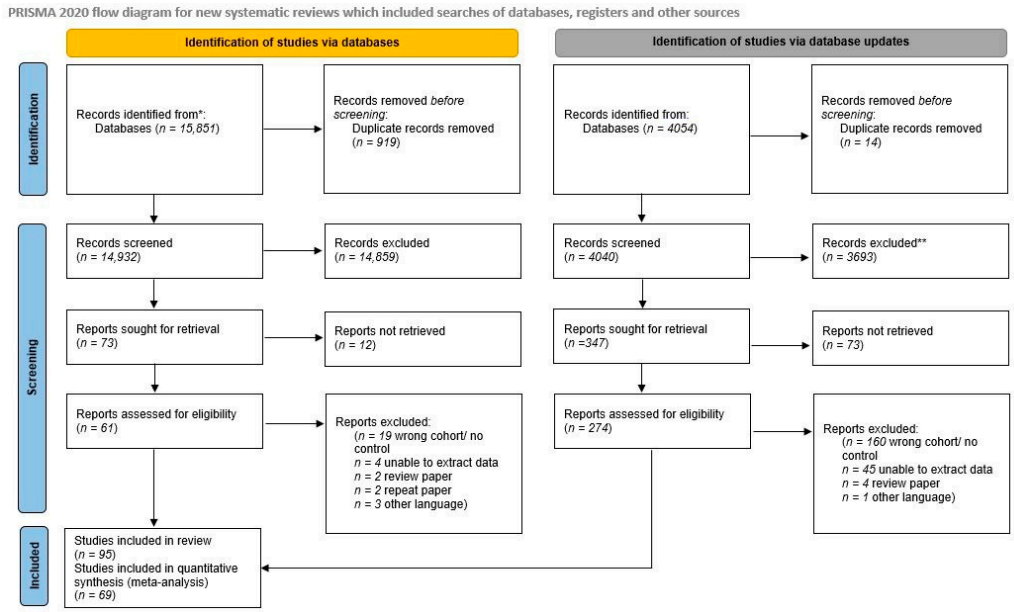

Figure 1. PRISMA 2020 flow diagram.

Table 2. Characteristics of studies included in the meta-analysis.

Study	Year	Country	Type of Study	Mean Age	Sex (% Male)	No. Patients with Hip fx	No. Patients w/o Fracture	NOS
Adams et al. [10]	2018	USA	Case–Control	NA	NA	1306	1477	8
Al-Algawy et al. [11]	2019	Iraq	Case–Control	NA	38	75	150	3
Albaba et al. [6]	2012	USA	Retrospective Cohort	NA	43	265	12,385	8
Albertsson et al. [12]	2010	Sweden	Prospective Cohort	79.0	0	7	278	6
Anastasilakis et al. [13]	2021	Greece	Case–Control	NA	0	37	32	7
Anpalahan et al. [14]	2014	Australia	Case–Control	NA	29	245	245	7
Ardiansyah et al. [15]	2019	Indonesia	Case–Control	75.1	26	82	82	7
Bartels et al. [16]	2019	Norway	Case–Control	65.0	23	50	150	7
Bruin et al. [17]	2020	UK	Cohort	81.3	27	23,780	44,583	8
Chang et al. [18]	2019	Taiwan	Cohort	74.1	18	166	147	9
Chen et al. [19]	2018	Taiwan	Case–Control	77.9	0	100	100	7
Dai et al. [20]	2018	Singapore	Cohort	56.5	44	2502	60,652	9
Enns-Bray et al. [21]	2019	Iceland	Case–Control	77.3	0	95	159	7
Fan et al. [19]	2018	China	Case–Control	74.4	0	277	272	7
Farahmand et al. [8]	2000	Sweden	Case–Control	71.5	0	1327	3262	7
Fernandez-Ruiz et al. [22]	2014	Spain	Cohort	74.3	42	166	5112	7
Fisher et al. [23]	2017	Australia	Cohort	78.8	33	455	385	7
Fox et al. [24]	2000	USA	Cohort	72.0	0	501	9190	9
Grisso et al. [25]	1997	USA	Case–Control	NA	100	356	402	7

Table 2. *Cont.*

Study	Year	Country	Type of Study	Mean Age	Sex (% Male)	No. Patients with Hip fx	No. Patients w/o Fracture	NOS
Hansen et al. [26]	2018	Denmark	Case–Control	73.9	31	37,500	37,500	6
Holvik et al. [27]	2019	Norway	Cohort	NA	49	1865	33,249	8
Hong et al. [28]	2021	South Korea	Case–Control	71.4	0	177	2285	7
Huang et al. [29]	1996	USA	Prospective Cohort	NA	0	130	2383	8
Humbert et al. [30]	2020	Spain	Case–Control	68.9	0	64	64	7
Hundrup et al. [31]	2005	Denmark	Cohort	NA	0	245	14,015	6
Hung et al. [32]	2018	Taiwan	Case–Control	75.4	0	762	7620	6
Hwang et al. [33]	2011	Taiwan	Case–Control	78.0	25	306	306	6
Iki et al. [34]	2021	Japan	Case–Control	59.3	0	68	1263	7
Jha et al. [35]	2010	India	Case–Control	NA	43	100	100	8
Kauppi et al. [36]	2014	Finland	Prospective Cohort	66.4	42	96	2204	7
Khandelwal et al. [37]	2012	USA	Retrospective Cohort	58.4	0	39	7145	6
Kim et al. [38]	2019	South Korea	Cohort	NA	39	3943	86,069	8
Komorita et al. [39]	2020	Japan	Cohort	65.0	57	110	4813	6
Lam et al. [40]	2020	China	Cohort	83.9	39	40	211	9
Leslie et al. [41]	2017	Canada	Cohort	64.3	0	1369	56,739	7
Lin et al. [42]	2020	China	Cohort	68.2	24	108	86	7
Lin et al. [43]	2021	Taiwan	Cohort	60.5	48	2061	51,167	9
Liu et al. [44]	2017	China	Case–Control	73.9	0	87	174	7
Liu et al. [45]	2020	China	Case–Control	65.0	0	286	286	7
Liu et al. [46]	2021	China	Case–Control	70.3	26	1064	1066	9
Lobo et al. [47]	2016	Spain	Cohort	73.4	42	275	4385	9
Min et al. [48]	2020	South Korea	Cohort	61.4	44	306	8265	8
Muhlberg et al. [49]	2019	France and UK	Cohort	75.9	0	40	55	6
Nakatoh et al. [50]	2021	Japan	Cohort	84.6	NA	2584	48,748	8
Papadimitriou et al. [51]	2017	Europe and USA (14 countries)	Cohort	NA	23	7724	223,880	8
Ramirez-Martin et al. [52]	2017	Spain	Case–Control	79.7	40	509	1315	7
Robbins et al. [53]	2005	France	Prospective Cohort	NA	0	293	7304	6
Robbins et al. [54]	2007	USA	Cohort	NA	0	1132	92,544	7
Ruiz et al. [55]	2019	Spain	Case–Control	NA	26	62	49	5
Saribal et al. [56]	2019	Turkey	Case–Control	70.5	30	40	40	7
Sarvi et al. [57]	2019	Canada	Case–Control	75.4	0	99	294	6
Shalev et al. [58]	2017	Isael	Case–Control	73.7	0	426	1278	9
Sharifi et al. [59]	2018	Iran	Case–Control	69.7	100	60	60	5
Su et al. [60]	2017	China	Cohort	72.4	50	128	3745	7
Su et al. [61]	2019	USA	Cohort	NA	100	172	5802	9
Takeshima et al. [62]	2017	Japan	Cohort	79.3	0	92	48	7
Torbergsen et al. [63]	2017	Norway	Case–Control	82.6	29	116	73	8
Turner et al. [64]	1998	USA	Retrospective Cohort	68.8	0	195	2130	6
Valentini et al. [65]	2018	Italy	Cohort	79.1	NA	62	50	7
Van den Eeden et al. [66]	2003	USA	Case–Control	NA	0	501	533	8
Wainwright et al. [67]	2005	USA	Cohort	NA	0	243	7822	9
Weber Silva et al. [68]	2017	Brazil	Case–Control	76.0	32	213	213	7
Wickramarachchi et al. [69]	2021	UK	Cohort	59.4	49	35	103	6
Yang et al. [70]	2018	USA	Cohort	75.1	100	170	486	8
Yu et al. [44]	2017	China	Case–Control	68.9	0	93	50	7
Yu et al. [71]	2021	USA	Cohort	53.9	52	204	14,994	7
Zhang et al. [72]	2017	China	Case–Control	70.7	26	1050	1050	7
Zhang et al. [73]	2021	USA	Cohort	74.2	49	127	4138	7
Zhuang et al. [74]	2020	China	Cohort	74.5	0	135	117	7

NOS: Newcastle–Ottawa Scale. NA: non-applicable.

2.3. Statistical Analysis

We included exposures of interest consistently reported by at least two studies in the meta-analysis. We collected odds ratios (ORs) and data from exposed participants to compute pooled effect sizes and 95% confidence intervals (CIs). In cases where variables had multiple levels (e.g., body mass index and parity), we designated one level as the reference and compared the remaining levels to this reference. If only crude data were available, we converted them to odds ratios to facilitate the generation of pooled ORs. Whenever possible, we prioritized ORs derived from multivariable analyses over those from crude or unadjusted data.

To analyze continuous data such as age or body mass index (BMI), we employed the standard mean difference (or Cohen's d) to measure effect size. This involved calculating the difference between the means of the two groups and dividing it by the pooled standard deviation to create a standardized measure of effect size. This approach allowed us to compare effect sizes across different studies. In cases where the standard deviation was not directly reported, we used estimation methods to infer it from other available statistics, such as standard error, confidence interval, or t-statistic. Similar to categorical data, we gave preference to effect sizes derived from multivariable analyses when such data were available. We considered p values below 0.05 as significant. We analyzed all data using Stata software (Stata Statistical Software: v18, StataCorp, College Station, TX, USA).

Two authors (NK and DY) assessed the methodologic quality of the studies using the Newcastle–Ottawa Scale (NOS), and a second author (KM) verified their assessments. To evaluate heterogeneity between studies, we used the I2 statistic. A random effects model was employed for the meta-analysis to calculate the pooled effects of risk factors on the risk of hip fracture. We utilized a funnel plot to assess publication bias and conducted the Egger test for risk factors when more than two studies were included [9]. We performed a sensitivity analysis in cases of publication bias. Supplementary figures, including funnel plots, are provided in Supplemental Figures S5–S17. The protocol for this study is registered at the PROSPERO register (ID = CRD42017073924).

3. Results

This meta-analysis included 69 studies containing 976,677 participants and 99,298 hip fracture cases. Cohorts reported in more than one study were only counted once when reporting the pooled number of cases and controls. The median age of the individuals included was 73.7 years (interquartile range of 53–85), and the median percentage of male participants was 25.5 (interquartile range of 0–100). In total, 66 of the 69 studies received a score of 6 or greater on the Newcastle–Ottawa Scale. The Egger test result for rank correlation was non-significant, and the funnel plot did not show asymmetry, indicating a low risk for publication bias, except for two risk factors (Table 3). The age and BMI of patients with hip fractures showed significant publication bias. Studies removed for publication bias were Anastasilakis et al. [13] regarding age and Anastasialkis et al. and Bartel et al. [13,16] regarding BMI.

The demographic risk factors significantly associated with an elevated risk of hip fracture were as follows: age $\geq$ 85 (OR 1.75; 95% CI 1.28, 2.38), BMI < 18.5 (OR 1.72; 95% CI 1.35, 2.18), female sex (OR 1.23; 95% CI 1.15, 1.32), history of falling (OR 1.88; 95% CI 1.43, 2.47), previous fracture (OR 3.16; 95% CI 2.08, 4.80), menopause (OR 7.21; 95% CI 4.29, 12.12), history of maternal hip fracture (OR 1.63; 95% CI 1.35, 1.98), unmarried and single (OR 1.70; 95% CI 1.38, 2.10), divorced (OR 1.38; 95% CI 1.01, 1.89), living in a residential care facility (OR 5.30; 95% CI 1.91, 14.75), and living alone (OR 1.47; 95% CI 1.15, 1.89). Age $\geq$ 65 (OR 1.66; 95% CI 0.40, 6.96), family history of osteoporosis (OR 0.95; 95% CI 0.68, 1.34), history of parental hip fracture (OR 1.42; 95% CI 0.94, 2.15), income quintiles (1st quintile: OR 0.86 and 95% CI 0.58, 1.28; 2nd quintile: OR 0.76 and 95% CI 0.48, 1.22; 4th quintile: OR 0.83 and 95% CI 0.56, 1.23; 5th quintile: OR 0.65 and 95% CI 0.43, 1.00), and being widowed (OR 1.36; 95% CI 0.91, 2.03) were non-significantly associated with hip fracture. Conversely, 25 < BMI < 30 (OR 0.59; 95% CI 0.45, 0.77), BMI > 30 (OR 0.38; 95% CI

0.18, 0.77), parity (≥1: OR 0.79 and 95% CI 0.69, 0.92; 1 ≤ parity < 3: OR 0.8 and 95% CI 0.71, 0.91; ≥3: OR 0.77 and 95% CI 0.63, 0.93), non-Caucasian descent (overall OR 0.4 and 95% CI 0.31, 0.52; Asian OR 0.36 and 95% CI 0.27, 0.48; Black OR 0.39 and 95% CI 0.23, 0.66; Hispanic OR 0.45 and 95% CI 0.33, 0.63), and rural residence (OR 0.95; 95% CI 0.92, 0.98) were significantly associated with a diminished risk of hip fracture (Table 4).

Table 3. Publication bias was assessed through the Egger test. **A**. Categorical risk factors. **B**. Continuous risk factors.

Risk Factor	Beta1	SE of Beta1	z	*p* Value
A				
Age	−1.63	3.187	−0.51	0.6085
Sex	−0.76	0.465	−1.62	0.1044
Ancestry	−0.71	0.685	−1.03	0.301
BMI	0.56	1.716	0.33	0.7448
Marital Status	0.73	0.791	0.92	0.3565
Parity	0.51	0.999	0.51	0.6129
History of Falling	0.12	0.767	0.16	0.8742
Previous Fracture	1.61	1.214	1.33	0.1843
Maternal Hip Fracture	−0.38	2.338	−0.16	0.8712
Parental Hip Fracture	1.26	1.445	0.87	0.3846
Residential Care Facility	2.49	2.16	1.15	0.2496
Rural	−0.32	0.771	−0.42	0.6765
B				
Age	7.31	1.423	5.13	0.00
		Excluding studies with bias		
	−1.18	1.771	−0.66	0.5063
BMI	−10.44	1.662	−6.28	0.00
		Excluding studies with bias		
	−0.01	0.852	−0.01	0.9945
Weight	0.87	0.754	1.15	0.2491
Height	0.57	1.383	0.41	0.6819

Table 4. Pooled odds ratios of risk factors with categorical data for sustaining a hip fracture.

Risk Factor		Number of Studies	Studies	Odds Ratio (95% CI)	*p* Value
Age	≥65	3	Al-Algawy (2019), Lin (2020), Turner (1998) [11,42,64]	1.66 (0.40, 6.96)	0.49
	≥85	3	Hung (2018), Kim (2019), Van den Eeden (2003) [32,38,66]	1.75 (1.28, 2.38)	<0.01
Sex	Male (reference)			1.00	
	Female	21	Al-Algawy (2019), Albaba (2012), Chang (2019), Dai (2018), Fernandez-Ruiz (2011), Fisher (2017), Holvik (2019), Kim (2019), Komorita (2020), Lam (2020), Lin (2021), Lin (2020), Lobo (2016), Min (2020), Papadimitriou (2017), Ramirez-Martin (2017), Ruiz (2019), Saribal (2019), Torbergsen (2017), Wickramarachchi (2021), and Yu (2021) [6,11,18,20,22,23,27,38–40,42,43,47,48,51,52,55,56,63,69,71]	1.23 (1.15, 1.32)	<0.01

Table 4. *Cont.*

Risk Factor		Number of Studies	Studies	Odds Ratio (95% CI)	*p* Value
Ancestry	White (reference)			1.00	
	Asian	4	Adams (2018), Khandelwal (2012), Robbins (2007), and Su (2019) [10,37,54,61]	0.36 (0.27, 0.48)	<0.01
	Black	8	Adams (2018), Grisso (1997), Robbins (2007), Su (2019), Turner (1998), Van den Eeden (2003), Weber Silva (2017), and Yu (2021) [10,25,54,61,64,66,68,71]	0.39 (0.23, 0.66)	<0.01
	Hispanic	5	Adams (2018), Robbins (2007), Su (2019), Turner (1998), and Yu (2021) [10,54,61,64,71]	0.45 (0.33, 0.63)	<0.01
	Non-Caucasian	9	Adams (2018), Grisso (1997), Khandelwal (2012), Robbins (2007), Su (2019), Turner (1998), Van den Eeden (2003), Weber Silva (2017), and Yu (2021) [10,25,37,54,61,64,66,68,71]	0.40 (0.31, 0.52)	<0.01
BMI	Normal (reference)			1.00	
	Underweight	6	Bruin (2020), Hundrup (2005), Hwang (2011), Lobo (2016), Turner (1998), and Weber Silva (2017) [17,31,33,47,64,68]	1.72 (1.35, 2.18)	<0.01
	Overweight	6	Bruin (2020), Hwang (2011), Lobo (2016), Ramirez-Martin (2017), Turner (1998), and Weber Silva (2017) [17,33,47,52,64,68]	0.59 (0.45, 0.77)	<0.01
	Obese	4	Lobo (2016), Ramirez-Martin (2017), Turner (1998), and Weber Silva (2017) [47,52,64,68]	0.38 (0.18, 0.77)	0.01
Marital Status	Married (reference)			1.00	
	Single and Unmarried	5	Farahmand (2000), Fernandez-Ruiz (2014), Grisso (1997), Hansen (2018), and Robbins (2007) [8,22,25,26,54]	1.70 (1.38, 2.10)	<0.01
	Divorced	6	Al-Algawy (2019), Farahmand (2000), Fernandez-Ruiz (2014), Grisso (1997), Hansen (2018), and Robbins (2007) [8,11,22,25,26,54]	1.38 (1.01, 1.89)	0.05
	Widowed	7	Al-Algawy (2019), Farahmand (2000), Fernandez-Ruiz (2014), Grisso (1997), Hansen (2018), Hwang (2011), and Robbins (2007) [8,11,22,25,26,33,54]	1.36 (0.91, 2.03)	0.13
Parity	0 (reference)			1.00	
	≥1	3	Farahmand (2000), Huang (1996), and Robbins (2007) [8,29,54]	0.79 (0.69, 0.92)	<0.01
	≥1 and <3	3	Farahmand (2000), Huang (1996), and Robbins (2007) [8,29,54]	0.80 (0.71, 0.91)	<0.01
	≥3	3	Farahmand (2000), Huang (1996), and Robbins (2007) [8,29,54]	0.77 (0.63, 0.93)	0.01
History of Falling		12	Albaba (2012), Albertsson (2010), Anpalahan (2014), Bruin (2020), Fox (2000), Hwang (2011), Lam (2020), Lin (2020), Liu (2020), Liu (2021), Su (2019), and Van den Eeden (2003) [6,12,14,17,24,33,40,42,45,46,61,66]	1.88 (1.43, 2.47)	<0.01

Table 4. *Cont.*

Risk Factor		Number of Studies	Studies	Odds Ratio (95% CI)	*p* Value
Previous Fracture		13	Albaba (2012), Albertsson (2010), Anpalahan (2014), Bruin (2020), Huang (1996), Lam (2020), Leslie (2017), Lin (2020), Liu (2021), Robbins (2007), Su (2019), Wainwright (2005), and Weber Silva (2017) [6,12,14,17,29,40–42,46,54,61,67,68]	3.16 (2.08, 4.80)	<0.01
Menopause		2	Dai (2018) and Huang (1996) [20,29]	7.21 (4.29, 12.12)	<0.01
Family History	Family History of Osteoporosis	2	Hundrup (2005) and Turner (1998) [31,64]	0.95 (0.68, 1.34)	0.77
	Maternal Hip Fracture	3	Fox (2000), Turner (1998), and Zhang (2021) [24,64,73]	1.63 (1.35, 1.98)	<0.01
	Parental Hip Fracture	6	Anpalahan (2014), Hwang (2011), Robbins (2007), Su (2019), Weber Silva (2017), and Zhang (2017) [14,33,54,61,68,72]	1.42 (0.94, 2.15)	0.10
Environmental	Living Alone	2	Min (2020) and Zhang (2021) [48,73]	1.47 (1.15, 1.89)	<0.01
	Residential Care Facility	4	Albertsson (2010), Anpalahan (2014), Fisher (2017), and Torbergsen (2017) [12,14,23,63]	5.30 (1.91, 14.75)	<0.01
	Rural	3	Al-Algawy (2019), Fernandez-Ruiz (2014), and Hansen (2018) [11,22,26]	0.95 (0.92, 0.98)	<0.01
Income	1st Quintile	2	Hansen (2018) and Shalev (2017) [26,58]	0.86 (0.58, 1.28)	0.46
	2nd Quintile	2	Hansen (2018) and Shalev (2017) [26,58]	0.76 (0.48, 1.22)	0.26
	3rd Quintile (reference)			1.00	
	4th Quintile	2	Hansen (2018) and Shalev (2017) [26,58]	0.83 (0.56, 1.23)	0.34
	5th Quintile	2	Hansen (2018) and Shalev (2017) [26,58]	0.65 (0.43, 1.00)	0.05

The age of the patients with hip fractures (Cohen's d 0.63; 95% CI 0.44, 0.82) was significantly higher than the non-fracture group. However, the hip fracture patients' weight (Cohen's d −0.23; 95% CI −0.3, −0.15) and BMI (Cohen's d −0.29; 95% CI −0.37, −0.21) were significantly lower than the non-fracture group. Age at menopause (Cohen's d −0.14; 95% CI −0.29, 0.02) and height (Cohen's d 0; 95% CI −0.13, 0.13) were not significantly different between the two groups (Table 5).

Table 5. Pooled Cohen's d values for hip fracture risk factors with continuous data.

Risk Factor	Number of Studies		Cohen's d (95% CI)	*p* Value
Age	34	Adams (2018), Albaba (2012), Chang (2019), Dai (2018), Enns-Bray (2019), Fan (2018), Fernandez-Ruiz (2014), Fisher (2017), Fox (2000), Huang (1996), Hung (2018), Hwang (2011), Iki (2021), Kauppi (2014), Komorita (2020), Leslie (2017), Lin (2021), Lobo (2016), Min (2020), Muhlberg (2019), Nakatoh (2021), Ramirez-Martin (2017), Robbins (2005), Sarvi (2019), Sharifi (2018), Su (2019), Su (2017), Takeshima (2017), Torbergsen (2017), Valentini (2018), Wickramarachchi (2021), Yu (2017), Yu (2021), and Zhuang (2020) [6,10,18–24,29,32–34,36,39,41,43,44,47–50,52,53,57,59–63,65,69,71,74]	0.63 (0.44, 0.82)	<0.01

Table 5. *Cont.*

Risk Factor	Number of Studies		Cohen's d (95% CI)	*p* Value
BMI	26	Adams (2018), Ardiansyah (2019), Bruin (2020), Chang (2019), Chen (2018), Dai (2018), Fan (2018), Farahmand (2000), Hong (2021), Huang (1996), Humbert (2020), Jha (2010), Komorita (2020), Leslie (2017), Liu (2017), Liu (2021), Lobo (2016), Min (2020), Su (2019), Su (2017), Takeshima (2017), Torbergsen (2017), Valentini (2018), Wainwright (2005), Yu (2021), and Zhuang (2020) [8,10,15,17–20,28–30,35,39,41,44,46–48,60–63,65,67,71,74]	−0.29 (−0.37, −0.21)	<0.01
Weight	25	Anpalahan (2014), Ardiansyah (2019), Chang (2019), Chen (2018), Enns-Bray (2019), Fan (2018), Fox (2000), Huang (1996), Humbert (2020), Iki (2021), Jha (2010), Kauppi (2014), Lam (2020), Leslie (2017), Liu (2021), Liu (2017), Muhlberg (2019), Robbins (2005), Robbins (2007), Sarvi (2019), Sharifi (2018), Su (2017), Takeshima (2017), Yang (2018), and Yu (2017) [14,15,18,19,21,24,29,30,34–36,40,41,44,46,49,53,54,57,59,60,62,70]	−0.23 (−0.30, −0.15)	<0.01
Height	20	Ardiansyah (2019), Chang (2019), Chen (2018), Enns-Bray (2019), Fan (2018), Fox (2000), Huang (1996), Humbert (2020), Iki (2021), Jha (2010), Kauppi (2014), Leslie (2017), Liu (2017), Muhlberg (2019), Robbins (2007), Sarvi (2019), Su (2017), Takeshima (2017), Yang (2018), and Yu (2017) [15,18,19,21,24,29,30,34–36,41,44,49,54,57,60,62,70]	−0.00 (−0.13, 0.13)	0.96
Menopause age	2	Chen (2018) and Hwang (2011) [19,33]	−0.14 (−0.29, 0.02)	0.09

4. Discussion

Although prior studies have described hip fracture risk associated with individual demographic factors, this is the first comprehensive review that includes multiple significant sociodemographic and lifestyle risk factors reported across various studies. This study represents extensive data from 69 papers with a cohort of 976,677 participants and 99,298 cases of hip fractures. Our meta-analysis evaluated diverse demographic features to report pooled odds ratios for hip fracture development. Among the examined factors, menopause (OR 7.21), residing in a residential care facility (OR 5.30), and having a history of previous fracture (OR 3.16) displayed the highest significant associations with hip fractures. Additionally, age over 85 years, female sex, underweight status, a family history of maternal hip fracture, being single and unmarried, living alone, and having a history of falls were all positively and significantly associated with an increased risk of hip fractures.

Conversely, significant protective factors against hip fractures included being overweight or obese, parity, Asian, Black, Hispanic, or non-Caucasian ethnicity, and residing in a rural area. A review of the molecular underpinnings of osteoporosis by Zhivodernikov et al. discusses important factors such as estrogen deficiency, inflammation, oxidative stress, cellular senescence, and genetic and epigenetic factors that mechanistically contribute to an imbalance in the remodeling process, leading to bone resorption and osteoporosis [75]. Our findings contribute valuable new insights to the current understanding of hip fracture risks, emphasizing the importance of considering individual sociodemographic profiles. This knowledge could be instrumental in suggesting modifications to established tools such as FRAX, leading to more personalized and effective prevention strategies for hip fractures.

4.1. Age

Studies have consistently demonstrated a positive correlation between increased age, elevated osteopontin (OPN) levels, and a decreased BMD index [76,77]. Furthermore, advanced age is linked to hormonal changes, notably a decline in women's estrogen levels, reduced muscle mass and strength, and impaired balance and coordination [67,78]. These factors collectively contribute to an increased risk of falls and subsequent hip fractures. A total of 29 out of the 34 studies that reported the mean age of both the hip fracture and non-fracture groups indicated significantly higher ages within the fracture group (pooled Cohen's d 0.63; 95% CI 0.44 to 0.82; $p < 0.01$) [6,10,18–24,29,32–34,36,39,41,43,44,47–50,52,53,57,59–63,65,69,71,74] (Figure 2). This finding aligns with earlier research highlighting decreased BMD with advancing age and heightened susceptibility to fractures among older, more vulnerable groups.

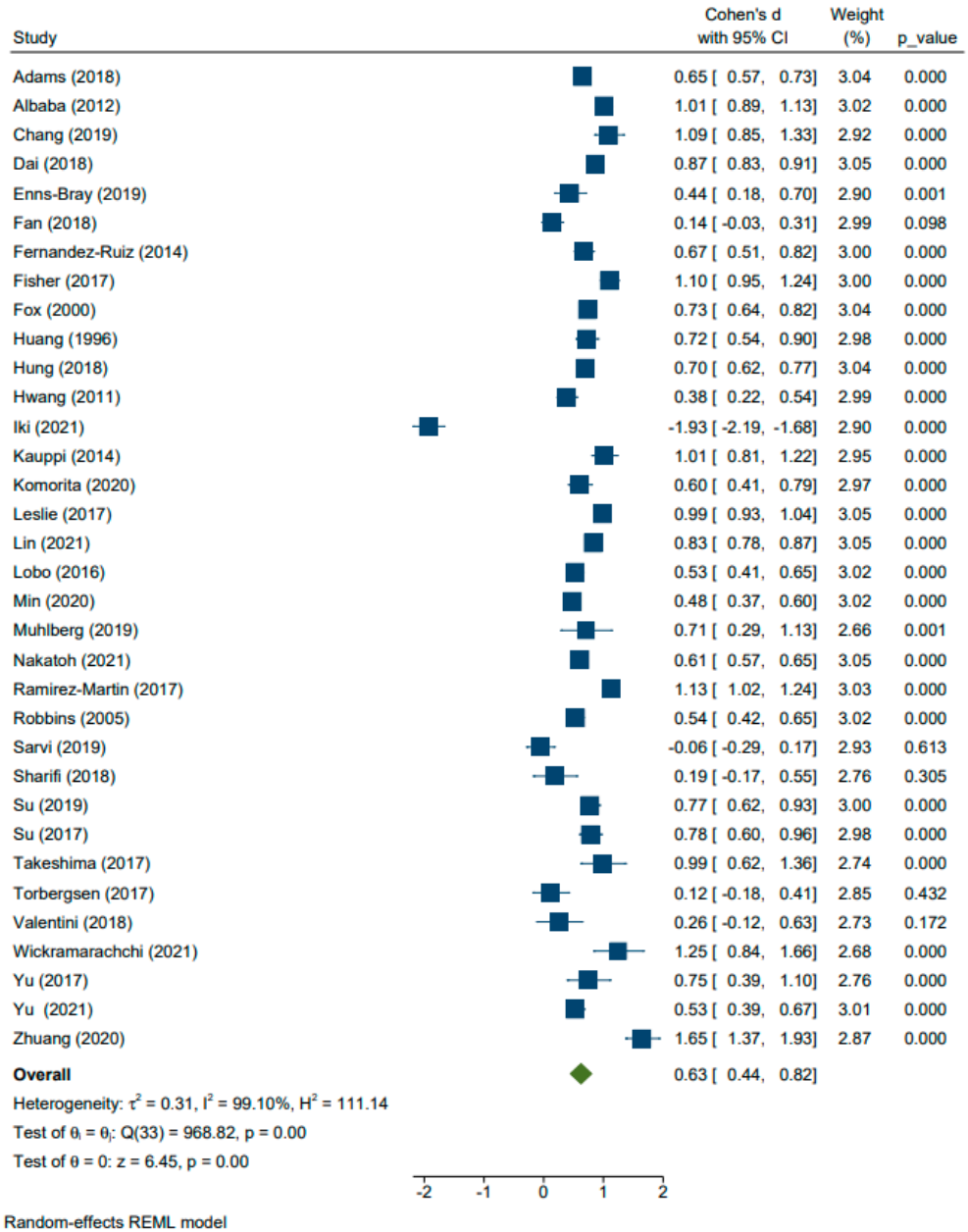

Figure 2. Forest plot demonstrating pooled effect size of age as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the green diamond represents the overall effect size [6,10,18–24,29,32–34,36,39,41,43,44,47–50,52,53,57,59–63,65,69,71,74].

Although a previous study by Turner et al. [64] delineated age over 65 as a threshold associated with significantly higher hip fracture risk, recent publications by Al-algawy et al. [11] and Lin et al. [42] did not observe a significant association between the age 65 and hip fracture; the pooled data from the current meta-analysis further confirms this, revealing that age over 65 is not significantly associated with hip fractures (pooled OR 1.66; 95% CI 0.40 to 6.96; $p = 0.49$) [11,42,64]. Notably, an intriguing pattern emerged when analyzing recent studies. Pooled data from these studies consistently indicate a significant association between age over 85 and hip fractures (pooled OR 1.75; 95% CI 1.28 to 2.38; $p < 0.01$) [32,38,66] (Figure 3).

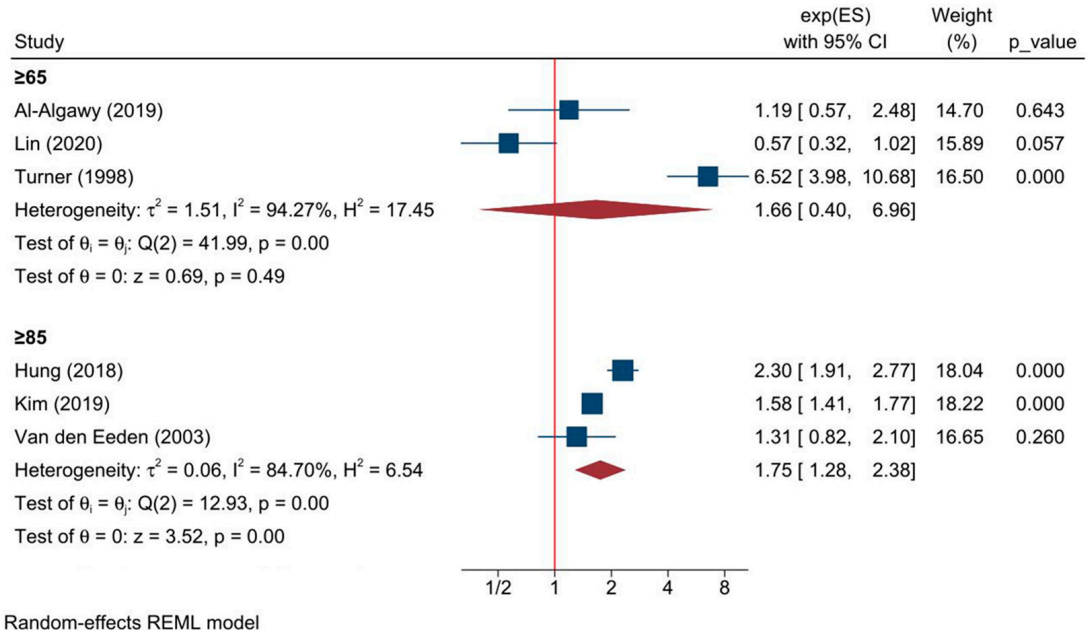

Figure 3. Forest plot demonstrating pooled odds ratio of age as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the red diamond represents the overall effect size. The red line serves as a reference point (OR = 1) against which the effects of individual studies are compared [11,32,38,42,64,66].

4.2. Sex

The increased risk of hip fracture among the female population is among the most well-understood demographic risk factors for hip fracture [6,20,27,38,43,47,48,52] (Figure 4). The decline in estrogen in post-menopausal women has been known to result in a progressive loss of BMD and a consequent elevated fracture risk [6]. In addition to this well-known explanation for the higher risk of hip fractures among women, several studies report associations between other variables and the female sex [33,79]. For example, falls are higher among women than men [79]. Similarly, studies show a stronger association between age and hip fracture risk among women than men [22]. In addition, diabetes is correlated with increased fall risk and hip fracture risk. This correlation is particularly strong for post-menopausal women due to a decline in BMD [33].

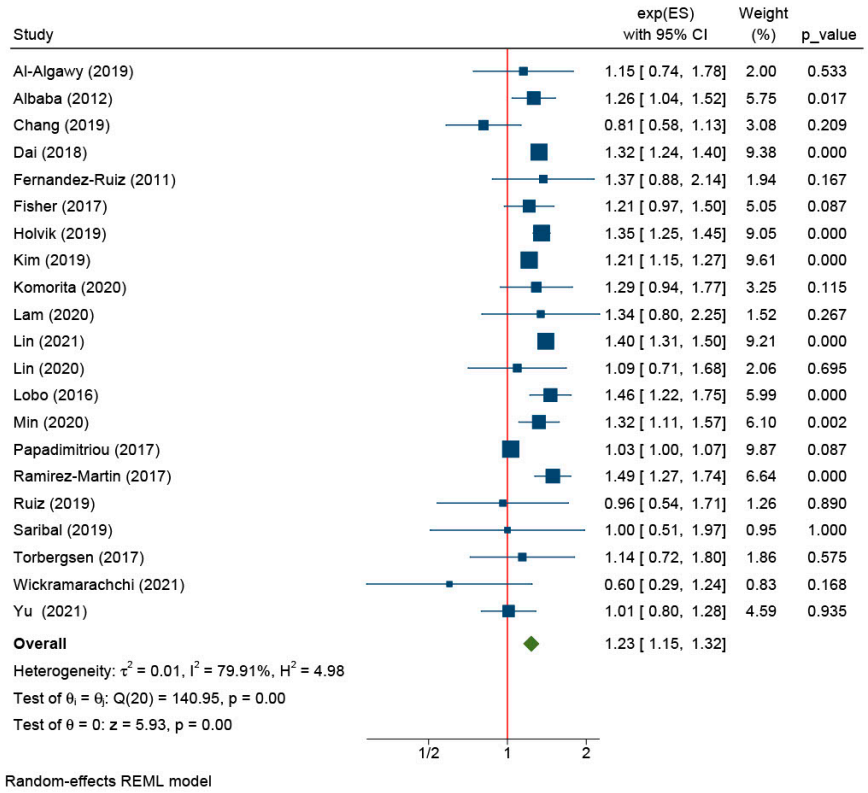

Figure 4. Forest plot demonstrating pooled odds ratio of sex as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the green diamond represents the overall effect size. The red line serves as a reference point (OR = 1) against which the effects of individual studies are compared [6,11,18,20,22,23,27,38–40,42,43,47,48,51,52,55,56,63,69,71].

4.3. Menopause

Studies were evaluated for the bivariate menopausal status as a risk factor for hip fracture outcomes among the female population. The decline in estrogen levels during menopause is a key factor influencing the risk of hip fracture. Estrogen is crucial in maintaining bone density and strength by regulating the balance between bone formation and resorption [80]. As estrogen levels decrease, this balance tilts toward bone resorption, gradually reducing bone mass and integrity. The pooled analysis within the current meta-analysis reveals a compelling finding: menopause emerges as the most substantial single risk factor linked to hip fractures (OR 7.21; 95% CI 4.29, 12.12) [20,29] (Figure 5). Interestingly, while menopause plays a pivotal role, the age at which menopause occurs does not appear to differ significantly between the groups of individuals with and without fractures [19,33] (Supplemental Figure S1).

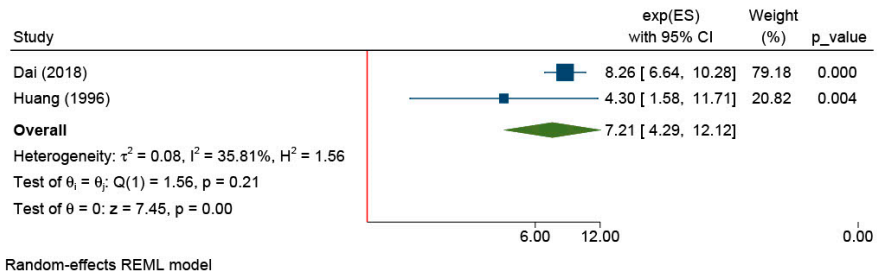

Figure 5. Forest plot demonstrating pooled odds ratio of menopause status as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the green diamond represents the overall effect size. The red line serves as a reference point (OR = 1) against which the effects of individual studies are compared [20,29].

4.4. Caucasian Ancestry

Ancestry has long been associated with the risk of hip fracture. Our combined analysis is consistent with prior studies that report a higher risk of hip fracture for white individuals than non-white individuals of Asian, Hispanic, or Black ancestry [10,25,37,54,61,64,66,68,71] (Figure 6). Some potential contributions to differences in relative risk include differences in genetic determinants of BMD, differences in hip morphology, differences in bone remodeling capacity, and lifestyle factors such as diet and nutrition [37]. With the global surge in osteoporotic hip fractures, it becomes imperative to enhance tools like FRAX to incorporate ancestry-based distinctions, particularly within under-represented ethnic communities. In addition, the growing diversity of the patient population in the United States justifies the need for further investigation into the underlying mediators between ancestry and the risk of hip fracture.

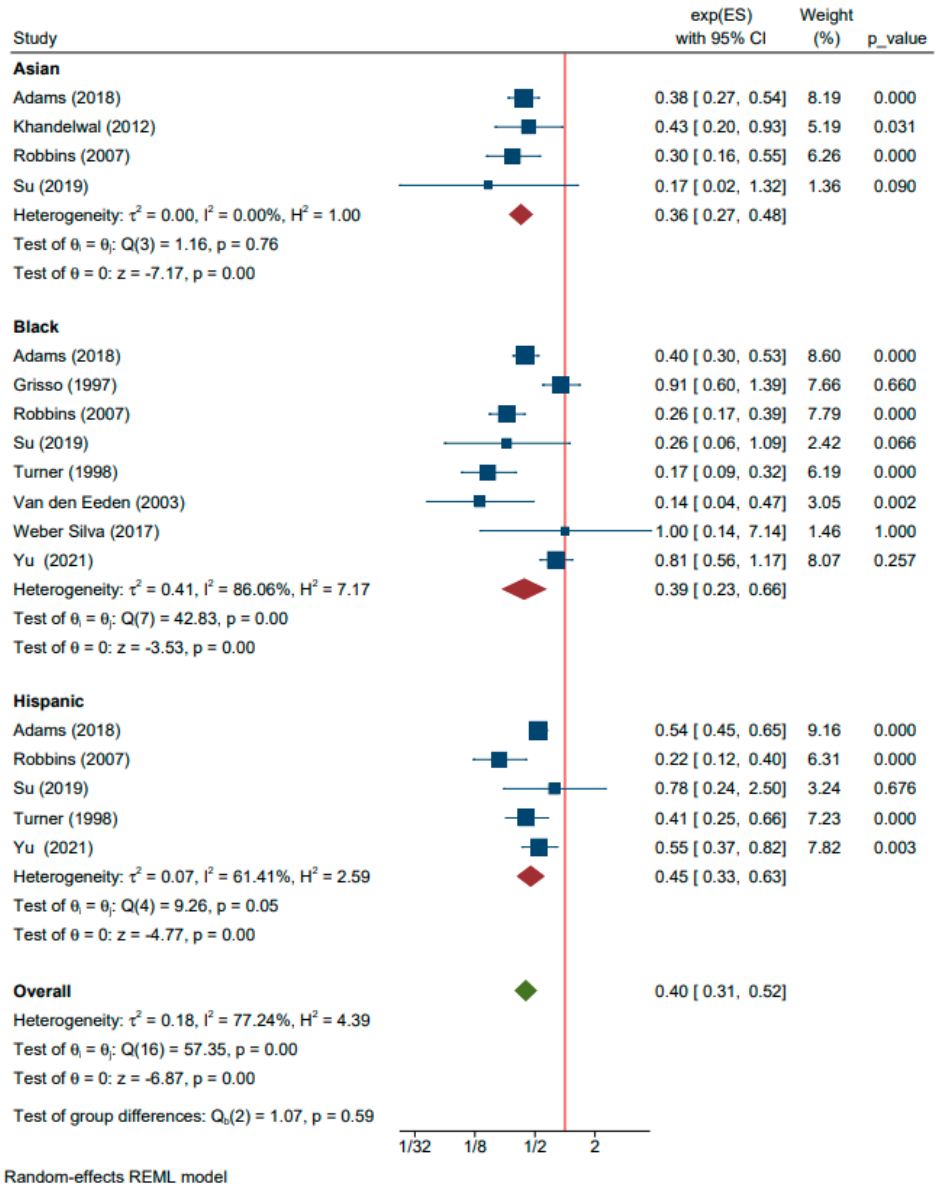

Figure 6. Forest plot demonstrating pooled odds ratio of ancestry as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the diamonds represents the overall effect size. The red line serves as a reference point (OR = 1) against which the effects of individual studies are compared [10,25,37,54,61,64,66,68,71].

4.5. BMI

The literature suggests that an increased BMI is protective against hip fractures. A lower BMI is associated with increased hip fracture occurrence. Conversely, a higher BMI is associated with a decreased hip fracture rate [81]. Studies also show a relationship between BMI and BMD, where higher BMD levels are associated with a higher BMI, partly explaining the protectiveness of BMI for hip fracture [82]. Similarly, our data show that being underweight (OR 1.72; 95% CI 1.35, 2.18; $p < 0.01$) [17,31,33,47,64,68] poses a significantly higher risk for fracture, while being overweight (OR 0.59; 95% CI 0.45, 0.77; $p < 0.01$) [17,33,47,52,64,68] and being obese (OR 0.38; 95% CI 0.18, 0.77; $p < 0.01$) [47,52,64,68] result in a significantly lower risk for fracture (Figure 7). Further data show hip fracture patients to have a lower BMI compared to patients with no hip fracture (pooled Cohen's d −0.29; 95% CI −0.37 to −0.21; $p < 0.01$) [8,10,15,17–20,28–30,35,39,41,44,46–48,60–63,65,67,71,74] (Supplemental Figure S2). BMI-associated findings are explained in relation to fatty tissue. Fat tissue provides cushioning and protects bones from impact, while peripheral fat is considered protective as it is an endogenous source of estrogen [81]. Being underweight can lead to osteoporosis, potentially due to decreased sources of estrogen [83].

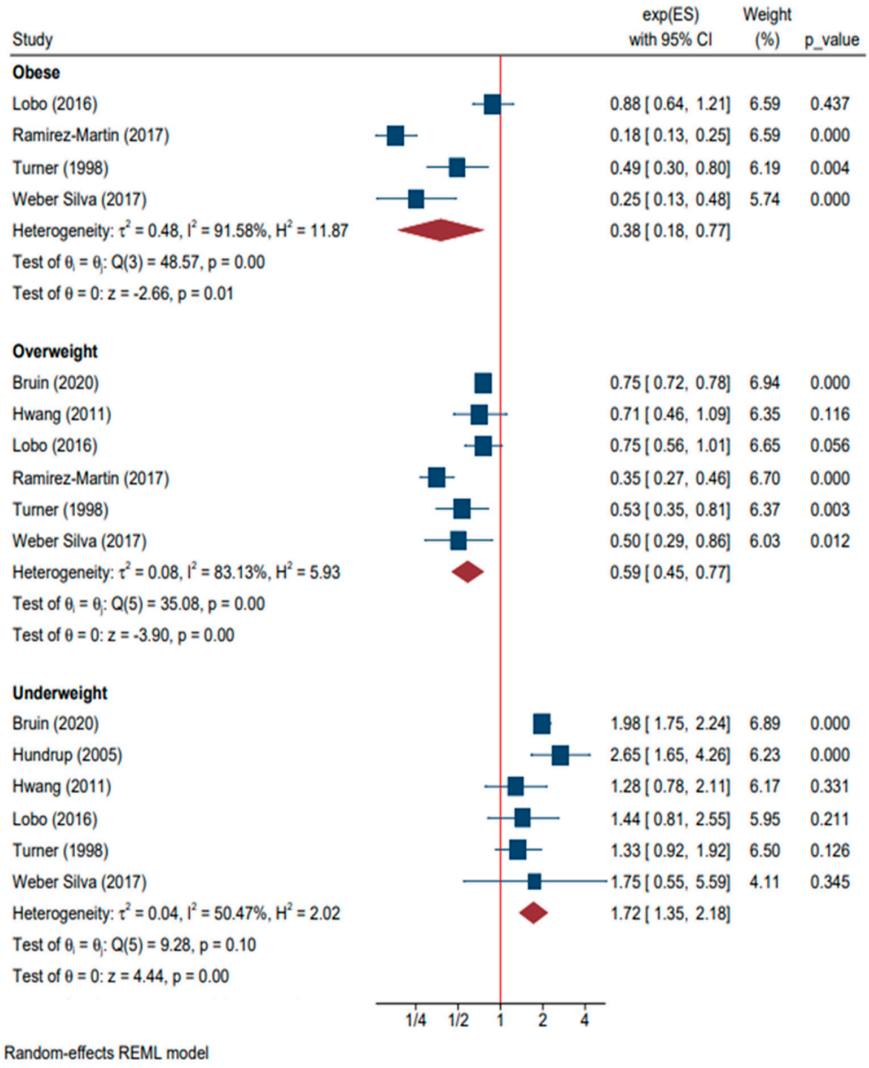

Figure 7. Forest plot demonstrating pooled odds ratio of BMI as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the red diamond represents the overall effect size. The red line serves as a reference point (OR = 1) against which the effects of individual studies are compared [17,31,33,47,52,64,68].

4.6. Parity

In our pooled analysis, bearing children was modestly associated with a decreased risk of hip fracture (OR 0.79; 95% CI 0.69, 0.92; $p < 0.01$) (Figure 8). Research regarding fracture risk and parity has been conflicting, and our analysis is consistent with most studies that report an association between nulliparity and elevated hip fracture risk [8,29,54]. Although the exact mechanism is poorly understood, this association is believed to result from a hormonal environment that impedes pregnancy and bone formation [54]. Paradoxically, while some studies report that high parity is associated with a reduced risk of hip fracture, others report that multiparity is associated with a higher risk of hip fracture [4,33]. Thus, it remains unclear whether childbearing is truly protective against hip fractures.

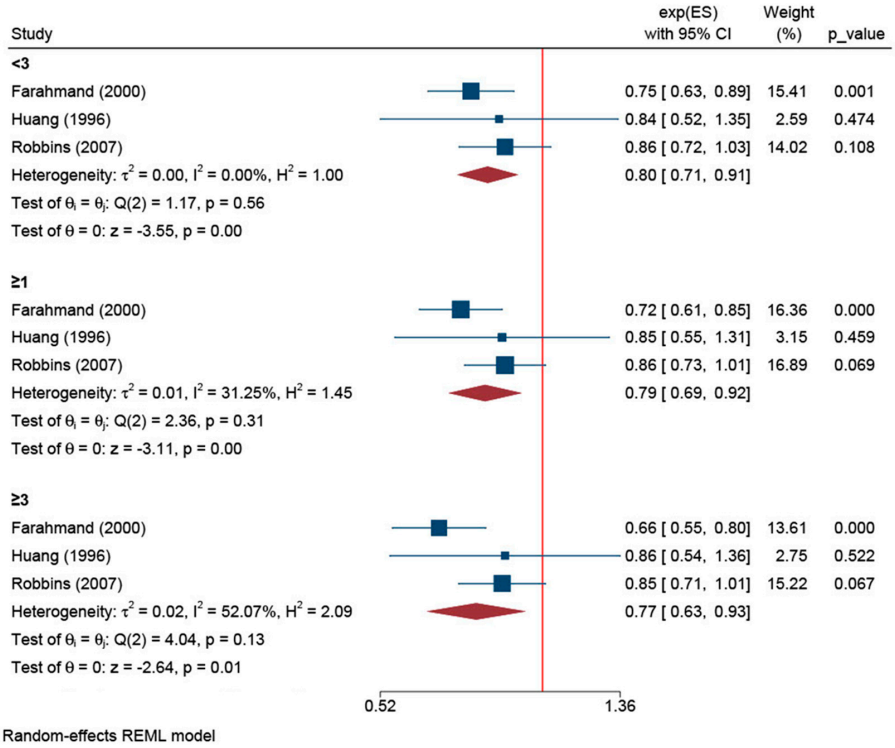

Figure 8. Forest plot demonstrating pooled odds ratio of parity status as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the red diamond represents the overall effect size. The red line serves as a reference point (OR = 1) against which the effects of individual studies are compared [8,29,54].

4.7. Marital Status

In addition to parity, marital status has been reported as a protective factor against hip fractures [6,24] (Supplemental Figure S3). Potential mechanisms for this beneficial effect include healthier lifestyle behaviors such as a more dynamic social life, a better diet, less need for medication, and more physical activity. In contrast, divorced, widowed, or single unmarried individuals may lead less active lifestyles and are possibly at higher risk of depressive disorders [22]. Similarly, among women who never married, those who lived alone reported higher rates of hip fractures than those who lived with another person [26,54]. Interestingly, Farahmand et al. [8] report that the association between marital status and hip fracture risk is stronger later in life than earlier.

Further, nursing home occupancy was shown to be more common in unmarried individuals, which may explain the stronger correlation between hip fracture and marital status in older adults [8]. Ultimately, this association must be interpreted cautiously since the lack of a partner may be confounded with old age. Nevertheless, marital status presents an intriguing avenue to explore the link between psychosocial well-being and morbidity in the elderly population.

4.8. Environmental Factors

Although less studied, living in a residential care facility was the second highest risk factor significantly associated with the risk of hip fracture in our pooled analysis (OR 5.30; 95% CI 1.91, 14.75) (Figure 9). Since the average age of residents in these facilities is often higher than that of individuals living independently, component studies implemented community matching to address potential confounders. One possible mechanism for this association between hip fracture risk and residential facilities is that institutionalized individuals experience low activity levels and impaired mobility. This results in poor bone mass and a higher risk of injury than community-matched peers [79]. Since individuals in residential care settings have limited outdoor exposure, vitamin D3 supplementation, and hip protectors have been implemented as protective measures against hip fractures [63,84].

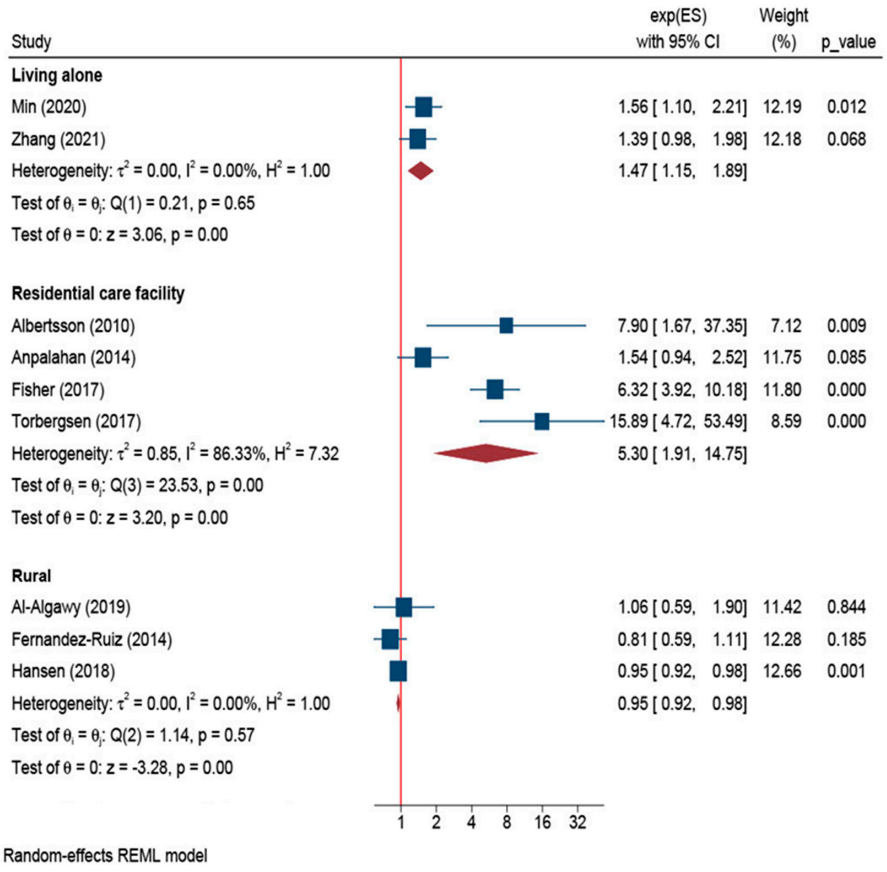

Figure 9. Forest plot demonstrating pooled odds ratio of residential status as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the red diamond represents the overall effect size. The red line serves as a reference point (OR = 1) against which the effects of individual studies are compared [11,12,14,22,23,26,48,63,73].

Nevertheless, institutionalization has been shown to predispose occupants of residential care facilities to this injury [79,85]. Additionally, living alone has consistently been linked to a heightened risk of hip fractures (OR 1.47; 95% CI 1.15, 1.89). This correlation could be attributed to the lack of a spouse or family members in the immediate vicinity [48,73]. The absence of a support system can render these individuals more vulnerable to the consequences of accidents, particularly falls that result in hip fractures. This emphasizes the pressing need for intensified medical and healthcare personnel attention to strengthen prevention and education efforts for this vulnerable group.

The lower hip fracture rates observed in rural areas can be attributed to factors promoting better bone health and reduced fall risks [11,22,26]. Rural residents frequently engage in physically demanding activities, fostering muscle strength and physical fitness.

Furthermore, traditional diets rich in fresh produce provide essential nutrients for strong bones. Although rural residence was associated with a significantly lower hip fracture risk, the odds ratio representing this association was only minimally lower (OR 0.95; 95% CI 0.92, 0.98).

4.9. Previous Falls

Falls represent the principal mechanism of injury in hip fractures [12]. For this reason, a history of falls puts patients at a greater risk of experiencing fractures (OR 1.88; 95% CI 1.43, 2.47) (Figure 10). Although skeletal factors such as BMD pose more significant risks to patients under the age of 80, the risk of falling becomes more concerning in older individuals [14]. Fall risk increases exponentially over the age of 80 due to increases in visual impairments, lower extremity neuropathies, and progressive muscle weakness [33]. Furthermore, some studies report that the direction and manner in which patients fall are essential to determining hip fracture risk [33,85]. In typical patients, it has been reported that a sideways fall increases the risk of hip fracture up to five-fold [85]. Changing the fall direction has been mentioned as a method for preventing hip fractures to avoid such unfavorable odds. Despite this evidence, not all studies have confirmed this association [14]. Further investigation is required to evaluate whether risk assessment tools that account for the history and direction of falls are more predictive of hip fracture risk than those that do not.

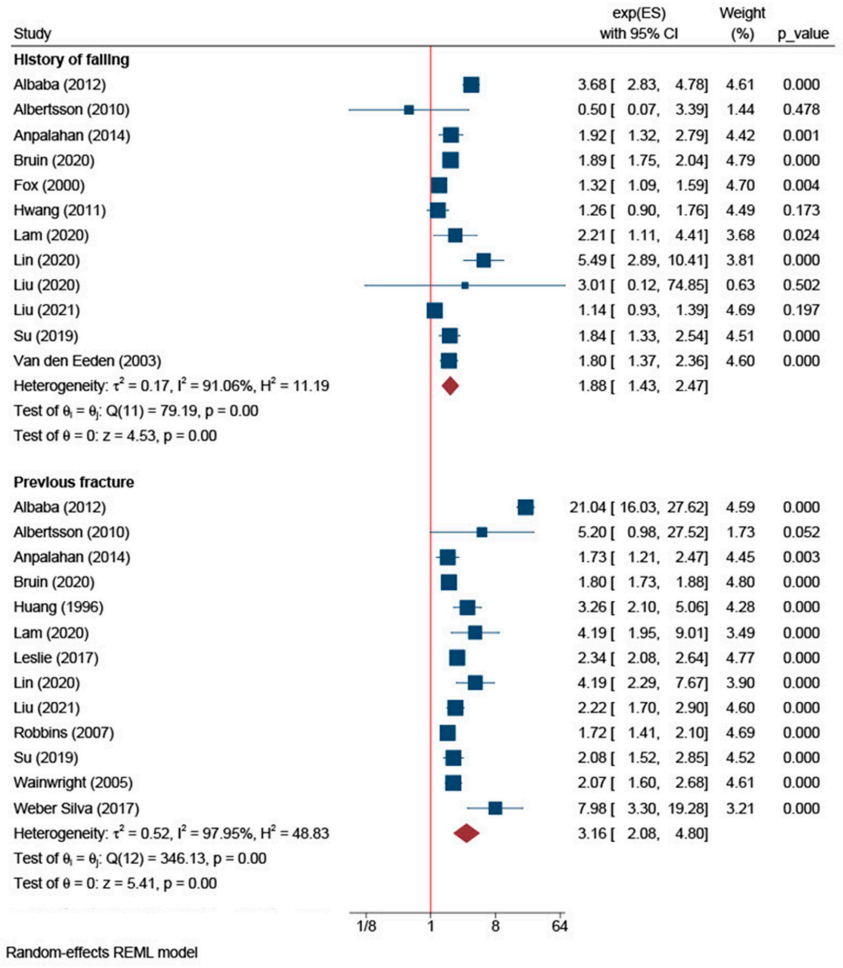

Figure 10. Forest plot demonstrating pooled odds ratio of history of falling and fractures as a risk factor for osteoporotic hip fracture. Box and whiskers represent each study with its 95% confidence interval and the red diamond represents the overall effect size. The red line serves as a reference point (OR = 1) against which the effects of individual studies are compared [6,12,14,17,24,29,33,40–42,45,46,54,61,66–68].

4.10. Previous Fractures

A history of previous fractures has been associated with an increased risk of future hip and spine injury, especially among older adults [6]. For this reason, fracture risk prediction models have considered prior fractures when evaluating individuals at risk. One such model is the Fracture and Mortality Index (FRAMO), based on four risk factors (age above 80 years, weight lower than 60 kg, prior fracture, and the need to use arms to rise) [12]. This model reports a significantly elevated fracture risk for women with previous fractures. A commonly accepted mechanism for this risk factor is that patients experiencing more frequent fractures have markedly lower global BMD. Spine BMD and a history of vertebral fractures are moderate predictors of hip fracture risk [85]. In this meta-analysis, a history of prior fractures had the third highest association with future hip fractures among all risk factors studied (OR 3.16; 95% CI 2.08, 4.80) (Figure 10). This is consistent with most studies, which report that previous fractures are among the strongest risk factors for future hip injury [6,14,17,29,40–42,46,54,61,67,68,86]. However, some studies report that a history of prior falls is more useful as a predictor of hip fracture for patients older than 80 years, while a history of prior fractures is a superior marker for those under 80 [14]. Further investigation is needed to make more definitive conclusions regarding the utility of previous fractures as a predictor of future hip fractures across age groups. While previous falls and fractures are correlated variables, we cannot draw conclusions based on the available data for all fall-associated fractures or types of falls that lead to higher fracture rates.

4.11. Family History of Hip Fracture and Osteoporosis

Prior studies have indicated a significant correlation between an individual's risk of hip fracture and the incidence of hip fractures among their parents [14,54,68]. This association is based on higher correlations between the bone densities of twins compared to other nuclear family members. Moreover, genetic factors contribute to the rapid decline in BMD in post-menopausal women [14]. For this reason, some studies have placed a special focus on maternal history of hip fracture when evaluating an individual's fracture risk. However, recent studies have shown a more nuanced relationship between hip fracture risk and family history of hip fracture. These studies report that at a younger age, a patient's parental hip fracture history is more of a determinant for fracture risk and less so as they age [14,24]. In older patients, falling is a much more significant risk factor. There is disagreement over the age at which the family history of hip fractures is no longer significant. One study reports that family history remains a strong predictor for patients until age 80 [14]. In contrast, another report states that family history is no longer significantly associated with hip fracture risk after age 50 [24]. Our pooled analysis shows a statistically significant correlation between hip fracture risk and family history. However, further study is warranted to determine the relationship between age and the predictive strength of family history (Supplemental Figure S4).

4.12. Fracture Risk Assessment

The FRAX, or Fracture Risk Assessment tool, was developed by the World Health Organization to calculate the risk of fractures more accurately, with or without factoring in BMD. Among the demographic risk factors elucidated earlier, FRAX encompasses solely sex, a history of fractures, and familial fracture history [7]. Our study highlights a range of sociodemographic risk factors that are significantly connected to the risk of hip fractures. This emphasis seeks to pave the way for more refined future models to enhance accuracy.

4.13. Limitations

Common limitations of meta-analyses include statistical heterogeneity and the quality of the papers included. The included studies were assessed using the Newcastle–Ottawa Scale, which found them all high quality. Although we prioritized data from multivariate analyses, it is possible that some confounders may not have been addressed in some of the original studies. Regarding marital status as a demographic risk factor for hip

fractures, a potential confounder could be old age since widowed individuals tend to be among older adults, with an inherently higher risk of hip fracture. Additionally, since this study synthesized data from observational studies, a causal inference cannot be drawn. While we did not explore the treatment options available for osteoporosis, identifying populations at risk can help us direct patient care through preventative care metrics such as nutritional care, lifestyle modifications, hormone therapy, and new emerging tools such as whole-body vibration, which has the potential to increase bone mass and density [9,87,88]. Nonetheless, exploring the literature allows for a holistic evaluation of the gaps in the current understanding and draws attention to areas of future study.

5. Conclusions

This is a large-scale meta-analysis of 976,677 participants and 99,298 hip fractures for a comprehensive review of sociodemographic factors. The data presented in this study indicate that being married, parity, BMI > 25, non-Caucasian descent, and rural residence diminish the risk of hip fracture. In contrast, age > 85, BMI < 18.5, female sex, previous falls, previous fractures, menopause, history of maternal hip fracture, being single and unmarried, being divorced, living in a residential care facility, and living alone are associated with elevated hip fracture risk. As such, healthcare providers should consider preventative measures for individuals at a higher risk of hip fracture based on these categories.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/osteology4020006/s1, Figure S1. Forest plot demonstrating pooled effect size of age at menopause as a risk factor for osteoporotic hip fracture. Figure S2. Forest plot demonstrating pooled effect size of BMI as a risk factor for osteoporotic hip fracture. Figure S3. Forest plot demonstrating pooled odds ratio of marital status as a risk factor for osteoporotic hip fracture. Figure S4. Forest plot demonstrating pooled odds ratio of family history of osteoporosis or hip fracture as a risk factor for osteoporotic hip fracture. Figure S5. Funnel plot for pooled effect size of age as a risk factor for osteoporotic hip fracture. Figure S6. Funnel plot for pooled odds ratio of age as a risk factor for osteoporotic hip fracture. Figure S7. Funnel plot for a pooled odds ratio of sex as a risk factor for osteoporotic hip fracture. Figure S8. Funnel plot for a pooled odds ratio of menopause status as a risk factor for osteoporotic hip fracture. Figure S9. Funnel plot for pooled effect size of age at menopause as a risk factor for osteoporotic hip fracture. Figure S10. Funnel plot for a pooled odds ratio of ancestry as a risk factor for osteoporotic hip fracture. Figure S11. Funnel plot for a pooled odds ratio of BMI as a risk factor for osteoporotic hip fracture. Figure S12. Funnel plot for the pooled effect size of BMI as a risk factor for osteoporotic hip fracture. Figure S13. Funnel plot for pooled odds ratio of parity status as a risk factor for osteoporotic hip fracture. Figure S14. Funnel plot for pooled odds ratio of marital status as a risk factor for osteoporotic hip fracture. Figure S15. Funnel plot for pooled odds ratio of residential status as a risk factor for osteoporotic hip fracture. Figure S16. Funnel plot for pooled odds ratio of history of falling and fractures as risk factors for osteoporotic hip fracture. Figure S17. Funnel plot for pooled odds ratio of family history of osteoporosis or hip fracture as a risk factor for osteoporotic hip fracture.

Author Contributions: Conceptualization, A.N., A.v.K., J.J.W., and P.A.; methodology, D.Y., K.M., A.M., S.J.M., I.R.B., D.C., N.K., M.M., J.J.W., and P.A.; formal analysis, D.Y., K.M., A.M., S.J.M., I.R.B., D.C., N.K., M.M., J.J.W., and P.A.; resources, A.N. and A.v.K.; writing—original draft preparation, D.Y., and K.M.; writing—review and editing, D.Y., K.M., A.M., S.J.M., I.R.B., D.C., N.K., M.M., J.J.W., P.A., A.v.K., and A.N.; visualization, D.Y., and K.M.; supervision, A.N.; project administration, A.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: All data generated or analyzed during this study are included in this published article [and its supplementary information files].

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

MEDLINE (Ovid) Search Strategy

Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily, Ovid MEDLINE and Versions(R)

(((exp hip fractures/OR ((hip OR hips) adj3 fracture*).ab,ti) AND (exp osteoporosis/OR osteoporo*.ab,ti)) OR ((exp osteoporotic fractures/OR (osteoporo* adj3 fracture*).ab,ti OR fragility fracture*.ab,ti) AND (exp hip/OR exp hip joint/OR hip.ab,ti OR hips.ab,ti)))

AND

exp risk/OR exp odds ratio/OR (risk OR odds ratio OR hazard ratio).ab,ti

PubMed Search Strategy

Years: 2017 to January 2022

("Hip Fractures"[MeSH] OR ("Hip"[tiab] AND "Fracture*" [tiab]) OR "Hip"[MeSH] OR ("Hips"[tiab] AND "Fracture*"[tiab]) AND ("Osteoporosis"[tiab] OR "Osteoporosis"[MeSH] OR "Osteoporotic Fractures"[tiab] OR ("Osteoporo*"[tiab] AND "Fracture*"[tiab]) OR "Fragility Fracture*"[tiab]) AND ("Hip Joint"[MeSH] OR "Hip"[MeSH] OR "Hip"[tiab] OR "Hips"[tiab]) AND ("Risk"[MeSH] OR "Odds Ratio"[MeSH] OR "Risk"[tiab] OR "Odds Ratio"[tiab] OR "Hazard Ratio"[tiab])

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