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Differences in Total Hip Arthroplasty Utilization Across Subspecialties and Practice Environments for Geriatric Displaced Femoral Neck Fractures: Secondary Analysis of Bullet Health Analysis (BHA) I

Clary J. Foote[1], Chirag Soni[2], Shaun P. Patel[3], Derek Moore[4,5], Jan P Szatkowski[2,4]*

[1]McMaster University, Hamilton, Canada
[2]Department of Orthopedics, Indiana University Health, Indianapolis, USA
[3]Department of Orthopedics, Southern California Permanente Medical Group, Irvine, USA
[4]Orthobullets, Santa Barbara, California, USA
[5]Santa Barbara Orthopedic Associates, Santa Barbara, USA

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***Correspondence:**
*Dr. Jan P Szatkowski, Department of Orthopedics, Indiana University Health, Indianapolis, USA;
Email: szatkowski@gmail.com

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Abstract

Purpose: The growing geriatric population has led to a sharp rise in geriatric displaced femoral neck fractures (DFNF). Global reporting is pivotal in deciphering surgeons' decision-making, managing geriatric DFNF. This study aims to further analyze the nuanced utilization preferences and stratifies these across various subspecialities, practice environments, and countries.

Methods: A longitudinal survey from 2020 to 2023 was conducted online via Orthobullets Case Studies, a global orthopaedic collaboration platform, to ascertain treatment preferences for geriatric DFNF. Standardized peer-reviewed polls were used to capture surgeon preferences for total hip arthroplasty (THA). A multivariable regression analysis assessed THA utilization odds across practice environments, subspecialities, and geographic factors, followed by a robust analysis to furnish precise estimates of THA preferences to represent the general population.

Results: Among the 2606 respondents surveyed, 51.5% expressed a preference for THA. Subspecialty preferences were distributed as follows: Arthroplasty (63.4%), Trauma (53.4%), General orthopaedics (51.4%), and Sports (40.2%). Notably, hospitals exhibited a higher inclination towards THA (53.3%) compared to private practices (41.2%) (i.e. one additional THA for every seven fractures managed in a hospital setting). Regression analyses unveiled a significant 3-fold odds difference in THA rates across diverse practice environments and subspecialties. Academic arthroplasty surgeons displayed a 5.4 times higher inclination for THA (i.e. two additional THAs for every five fractures encountered).

Conclusion: Practice environment profoundly influences THA utilization for geriatric DFNF. The study findings underscore the critical need for future trials, advocating for randomized evaluations across subspecialties, geographical regions, and varied practice settings to holistically inform best practices in orthopaedic care.

Level of Evidence

Level III Surgical Practice Survey (Global Practice Trends).

Introduction

Global demographics are rapidly changing, with projections anticipating a doubling in the population aged 65 or older by 2030 compared to 2019[1]. This shift coincides with a notable increase in disabilities among older adults, especially in terms of physical limitations[2]. Hip fractures, displaced femoral neck fractures (DFNF) in particular, have surged sevenfold since 1990, exceeding previous forecasts[3]. World Health Organization (WHO) and United

Nations (UN) data highlight two key trends: a steep rise in individuals aged 65 and older and associated increase in life expectancy for those with chronic diseases among geriatric populations[4].

Despite the growing aging population, effectively managing DFNFs in patients over 60, remains a challenge. Clinical trials favour arthroplasty, yet a debate persists regarding the efficacy of total hip arthroplasty (THA) versus hemiarthroplasty (HA)[5]. Understanding orthopedic surgeons' preferences for THA in displaced femoral neck fractures among older patients is crucial for several reasons. Global reporting provides insights into geographical variations of these determinants and serves as a foundation for refining evidence tailored to diverse subspecialties, regions, and practice settings. This data also informs innovative trial designs by integrating "higher-order factors" beyond patient characteristics for context-specific outcomes.

The impact of surgeon- and practice-related factors on the choice of arthroplasty globally remains uncertain. Discerning these factors are important to understand practice patterns that are not commonly analyzed in larger clinical trials, especially given the increased incidence of DFNF and variation in treatment options. In response, the Worldwide Orthopaedic Research Collaboration: Leveraging Big Data (WOLRD) initiated a global survey to understand determinants of surgical management for DFNF in a series titled Bullet Health Analysis (BHA). In the first series, BHA I reported that there is a significant increase in THA utilization and a predominance of cement femoral fixation in the United Kingdom[6]. Increases in THA preference may stem from recent literature reporting that THA may not have greater rates of morbidity and secondary operations as previously thought[5]. In a continuation of the BHA series, we present BHA II conducted to furnish precise estimates establishing representativeness compared to the overall respondent pool, supported by 95% confidence intervals, delineating surgeon preferences for THA in geriatric DFNF. This analysis offers detailed insights across various subspecialties and practice environments, illuminating THA preferences in diverse settings for each subspecialty.

Materials and Methods

Survey Development

In 2020, a team of orthopaedic surgeons from various specialities designed a thorough survey to explore treatment preferences for geriatric DFNF among orthopedic professionals. This case-based questionnaire, accredited for Continuing Medical Education (CME), was distributed through Orthobullets, an online global orthopedic education platform with 200,000 members.

The survey methodology centers around clinical cases preceding surveys. The inclusion of clinical cases ahead of the survey optimizes surgeon recall of similar cases facilitating more focused responses within a familiar clinical context. Orthobullets.com has a team dedicated of content and methodological experts with various specialized orthopaedic backgrounds deploying surveys pertaining a wide range of topics in orthopaedic practice.

The survey featured a scenario of a Garden IV DFNF in an elderly patient who was previously an ambulatory community member followed by a 13-item questionnaire. The adjunct survey accompanying the clinical scenario covered diagnostics, preventive strategies, intervention timing, and surgical management preferences of DFNF in patients similar in age and functional status to the patient mentioned in the clinical scenario. The survey also collected detailed demographic data, including country, practice type, subspecialty, and practice environment. The full survey can be found in Appendix 1.

Survey Administration

The survey was available online from April 2020 until June 2023, presenting the aforementioned clinical case to orthopedic professionals. Distribution occurred via email to members of the education platform. Extensive outreach efforts were undertaken across social media channels to stimulate participation. Robust measures were implemented to safeguard data integrity throughout the survey.

Before the survey, we introduced a detailed clinical case featuring an elderly, active-smoking woman. This case included socio-demographic data and three radiographs (Figures 1A to 1D). Presenting this case before the survey,

Figure 1A: Anteroposterior Radiograph Pre-Survey Clinical Case Presentation
This anteroposterior radiograph illustrates the clinical scenario of a 76-year-old female smoker who experienced a mechanical fall. She was an active community ambulator and had a history of ambulation. These radiographs were provided before surveying geriatric displaced femoral neck fractures.

Figure 1B: Supplementary Right Hip Anteroposterior Radiograph
This dedicated right hip anteroposterior radiograph was included in the clinical case provided to respondents before the survey for reference.

Figure 1C: Supplementary Cross-Table Lateral Radiograph
Additional cross-table lateral radiographs were included within the clinical case for respondents' reference before the survey. This image allowed surgeons to evaluate the tilt of the femoral neck and head in the sagittal plane.

as per established evidence-based practices, aimed to enhance memory recall among respondents. This approach aids in recalling clinical cases and decision-making processes, especially concerning geriatric displaced femoral neck fractures[7].

Data Verification

To address the potential sampling bias given that the Orthobullets platform is widely used by orthopaedic

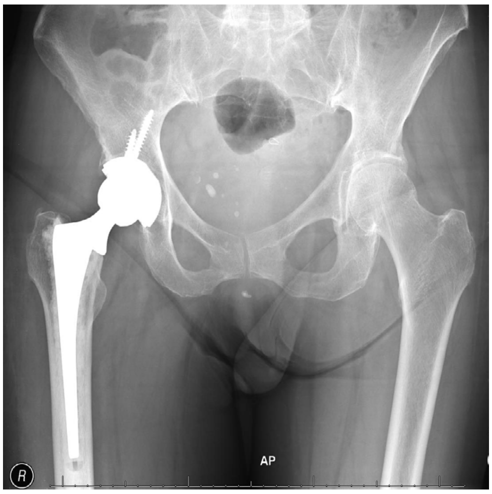

Figure 1D: Supplementary Post-operative Anteroposterior Radiograph
This anteroposterior radiograph illustrates the treatment method used in this specific clinical scenario.

residents and fellows, only responses from validated practicing surgeons were included in the analysis. A comprehensive multimodal data algorithm was utilized to validate physicians to ensure data integrity. The algorithm consisted of the following criteria: national provider identifier (NPI) number, Pubmed publications, medial school attended, year of graduation, affiliation with academic institutions, assessment of years in practice, social media mapping for professional networking, and purchase history related to medical education resources. These measures were taken to mitigate risk of false data provided in survey responses. These methods strengthened reliability and validity of the data used in the analysis to the best of the authors ability.

Primary and Secondary Outcomes

Primary Outcome

- Comparative assessment of THA utilization between hospital based and private practice environments.

Secondary Outcomes

- Calculate predicted percentages with 95% confidence intervals for respondents to establish representativeness of respondents within subspeciality (General, Sports, Trauma, and Arthroplasty) and practice environment respondent pool.
- Perform meta-analytic comparisons of THA utilization rates between hospital-based and private practice settings for each subspeciality to assess overall heterogeneity.
- Analyze difference in odds, with 95% confidence intervals, in choosing THA between arthroplasty and non-arthroplasty surgeons.

- Evaluate heterogeneity across countries in rates of surgeon favouring THA for each subspeciality.
- Conduct multivariable regression analysis to determine percentage difference in THA preference associated with specific subspecialties and countries to assess independent influences of geography and subspeciality on THA utilization.

Statistical Analysis

We estimated THA utilization rates across various subspecialties and practice environments, furnishing nuanced estimates for selected countries. Primary analyses compared hospital-based settings with private practices, generating odds ratios. Subgroup analyses delved into comparisons across major orthopedic subspecialties, while regression analyses scrutinized the impact of geographical factors and subspecialties on THA utilization rates.

The study utilized multivariable Bayesian regression to analyze Total Hip Arthroplasty (THA) rates, complemented by metaregression (THA Rates) and multivariable logistic regression using individual surgeon data. Additional model specifics are detailed in Appendices 1.0 and 2.0. Model significance was determined by overall p-values adhering to conventional statistical thresholds ($p \leq 0.05$ for frequentist models). Credible intervals were reported for Bayesian models, consistent with accepted statistical standards, ensuring representativeness through percentage meta-analysis. All statistical tests were two-tailed, with significance set at 0.05. Supplementary materials containing additional methodological details, forest plots, and graphical representations of primary analyses are available in Appendices 1.0 and 2.0.

GRADE Approach to Survey Reporting

We employed the GRADE approach to report the findings of this study[8] . Further details regarding the results of the GRADE process can be found in Table 1, in the supplementary material.

Results

Characteristics of Respondents

Of the 2606 respondents, 2392 (91.8%) disclosed their subspecialization during registration, accounting for 62.9% to 74.8% of survey viewers. Among these, 1752 (74.3%) categorized themselves as generalists while 615 (25.7%) specified a subspeciality. Additionally, 1056 (44.7%) revealed their practice environment, which was distributed across academic hospitals (12.1%), non-university affiliated hospitals (34.3%), or private practices (53.6%). The respondents' geographic distribution was as follows: 38.8% from North America, 32.1% from Europe, 10.8% from Asia, 7.0% from the Middle East, 2.3% from Africa, 2.3% from Latin America.

Impact of Practice Environment on THA Preference

The weighted percentage of THA preference among respondents specifying their practice environment was 48.7% (95% CI 39.9 to 57.5%), suggesting representation of the entire cohort (51.5%, 95% CI 49.6 to 53.4%). Large hospital systems favoured THA 53.3% of the time (95% CI 49.6 to 57.0%), while private practice leaned towards HA, with 41.2% favouring THA (95% CI 36.1 to 46.2%) (Difference: 13.3%, 95% CI 8.0 to 18.6%, p<0.001). Comparative analysis showed 1.69-fold higher odds of preferring THA in large hospital environments versus private practice (OR 1.69, 95% CI 1.31 to 2.17, p<0.001).

Visual representations in Figure 2 exhibit THA preferences by subspecialty across large hospital-based systems and private practice, highlighting preference variations. Figure 3, a Forest plot, demonstrates the meta-analytic aggregate rate of THA preference within subspecialties and practice environments. Significant conclusions should be drawn from comparative odds ratio estimates in Figure 2 rather than heterogeneity tests in Figure 3 as detailed by the internal validity and validation analyses in BHA Appendix 2.

Variation in Total Hip Arthroplasty Use Among Subspecialties

Among respondents reporting their subspecialty, the

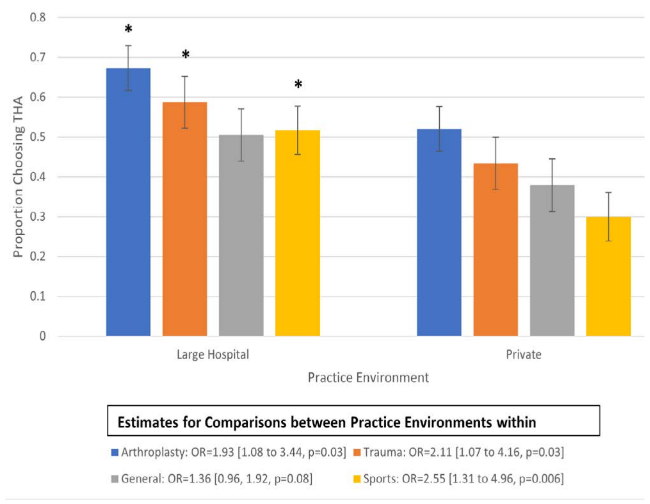

Figure 2: Diagram Illustrating Surgeon Preferences for THA Across Subspecialties and Practice Types
This diagram displays the proportions of respondents who chose THA, categorized by practice type (Hospital-based vs. Private Practice). The legend indicates the corresponding odds ratios with 95% confidence intervals derived from hospital-based versus private practice comparisons for each subspecialty. Across subspecialties, hospital-based surgeons preferred THA more in geriatric displaced femoral neck fractures. Generally, hospital-based surgeons had 1.7 times higher odds of preferring THA than private practice surgeons (OR 1.69, 95% CI 1.31 to 2.17, p<0.001). Error bars represent 95% confidence intervals of the proportion. *p<0.05.

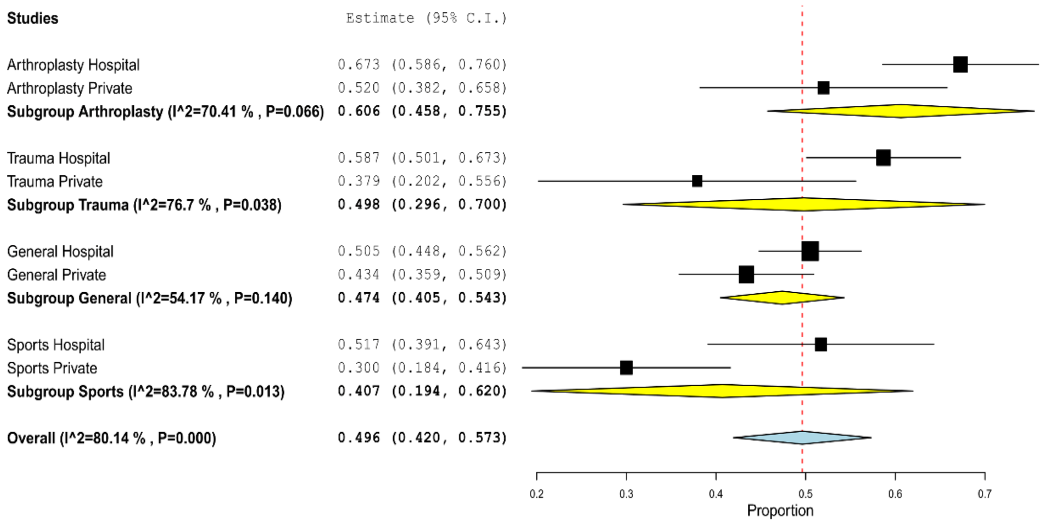

Figure 3: Forest Plot Depicting THA Preferences by Subspecialty
This forest plot illustrates proportions choosing total hip arthroplasty (THA) with 95% confidence intervals (CI), substratified by subspecialty. Estimates for hospital-based systems (academic and non-university large hospitals) and private practice are provided for each subspecialty, along with meta-analytic aggregate estimates. Statistical significance can be inferred from 95% CI (overlap between estimates) and p-values for heterogeneity.

weighted preference for THA was 52.3% (95% CI 45.2 to 59.3%), aligning with the overall respondent pool (51.5%, 95% CI 49.6 to 53.4%), confirming representativeness. Subspecialty-wise THA preferences were: arthroplasty 63.4% (95% CI 56.7 to 70.0%), trauma 53.4% (95% CI 47.2 to 59.6%), general orthopaedic surgery 51.4% (95% CI 49.1 to 53.7%), and sports 40.2% (95% CI 32.6 to 47.9%) ($p<0.001$). A subgroup meta-analysis for arthroplasty versus non-arthroplasty surgeons showed THA utilization rates of 63.4% (95% CI 56.7 to 70.0%) versus 49.1% (95% CI 42.9 to 59.3%, Test for Heterogeneity: $p<0.001$). A meta-analysis of surgeons who had a practice type resulted in similar THA rates with an analogous gradient of utilization across subspecialties (Figure 3).

Raw analysis (i.e. count approach) of THA rates between arthroplasty and non-arthroplasty surgeons resulted in a 12.7% higher THA preference (95% CI 5.1 to 20.3%, $p=0.001$) among joint specialists (OR 1.67, 95% CI 1.24 to 2.26, $p=0.001$). Meta-analytic subgroup analysis demonstrated arthroplasty subspecialization was associated with a 14.3% increment in the THA rate (95% CI 7.1 to 21.5%, $p<0.001$). Unadjusted simple metaregression provided a slightly more modest estimate than subgroup analysis in favour of arthroplasty surgeons (13.6% higher THA, 95% CI 4.4 to 22.9%, $p=0.004$). Yet, after adjusting for practice type, the arthroplasty subspecialty showed a 19.8% increase in THA utilization (95% CI 8.3 to 31.2%, $p<0.001$). Academic arthroplasty surgeons were 5.4 times more inclined towards THA than private sports surgeons (95% CI 2.09 to 14.2, $p=0.001$).

We conducted a multivariable binary logistic regression analysis involving practice type and subspecialty, with an interaction term between these covariates. The findings revealed a threefold increase in the THA rate for hospital-based arthroplasty specialists compared to non-arthroplasty surgeons in private practice (OR 3.13, 95% CI 1.76 to 5.57, $p<0.001$).

The interaction term generated nuanced THA rates, demonstrating a gradient of increasing utilization correlated with hospital-based practice and arthroplasty specialization. In hospital based settings, arthroplasty specialities demonstrated an increased estimated THA rate compared to non-arthroplasty based specialities, 67.3% (95% CI: 58.0% - 75.4%) versus 52.8% (95% CI: 48.3% - 57.2%), respectively. In private practice settings arthroplasty based specialities demonstrated an increased estimated THA rate compared to non-arthroplasty based specialities, 52.0% (95% CI: 38.3% - 65.4%) versus 39.6% (95% CI: 33.8% - 45.7%) respectively.

Geographic Impact of THA Utilization

Survey analysis demonstrated notable variations in THA preferences across subspecialties. Arthroplasty-trained surgeons displayed minor variation ($I^2=0\%$, $p=0.91$) across countries including the US, UK, Canada, Australia, and India, whereas generalists (I2=50.3%) and traumatologists ($I^2=85.3\%$) showed substantial variability in THA preferences among the analyzed countries (US, UK, Canada, Australia, India, Germany). Figure 4 presents meta-analytic estimates showcasing THA utilization rates across selected countries. Subsequent Bayesian multivariable regression analysis, as detailed in Table 2 (adjusting for geographic status), revealed significant associations between subspecialization and THA utilization. Arthroplasty specialization showed a notable 22.4% increase in THA utilization (95% CrI 18.7 to 26.1%) compared to traumatologists.

Orthopaedic trauma specialists formed the baseline THA rate of 37.4% (Crl 33.4 to 41.3). When we adjusted the Bayesian model to group all non-arthroplasty specialties (Sports, Trauma, and General Orthopaedics), arthroplasty surgeons exhibited a 21.4% higher THA rate (95% CrI 18.3 to 24.5%), akin to the results when traumatologists were the reference group in the principal Bayesian model.

Adjusted THA rates for non-arthroplasty and arthroplasty surgeons were derived from the Bayesian model. A percentage odds estimate and 95% confidence interval were calculated to clarify the observed THA rate discrepancy. Arthroplasty specialists exhibited a 2.4-fold higher THA utilization rate than non-arthroplasty surgeons (OR 2.39, 95% CI 1.54-3.7, $p<0.001$).

Notably, the United Kingdom and Australia demonstrated higher THA frequencies than the United States, performing approximately one additional THA per five cases. Conversely, Canada tended to perform THA less frequently, with roughly one less THA per ten cases. Other countries showed THA preferences similar to the baseline.

The frequentist analysis in the Appendix yielded a p-value of <0.001, signifying statistical significance. The Bayesian model used credible intervals instead of p-values, aligning with the robustness of the Bayesian approach. The credible intervals, as shown above and reported in Table 2, corroborated the findings obtained from the frequentist model.

Discussion

Hip fractures place a significant burden upon the healthcare system. Clinical trials favour arthroplasty opposed to open reduction internal fixation as studies have shown an increase in revision rates establishing arthroplasty as the standard of treatment[9,10]. Consensus regarding optimal arthroplasty choice is more limited. In a meta-analysis by Migliorini et al., it was reported that trials with less than five years of follow up reported reduced revision in favour of HA while trials with greater than five years of follow up revealed reduced revisions for THA[11]. This can potentially be explained by the progression of acetabular erosion in HA requiring conversions to THA which would be increased in patients with greater follow up[12]. While previous studies have reported an increased dislocation rates with THA, more recent studies such as

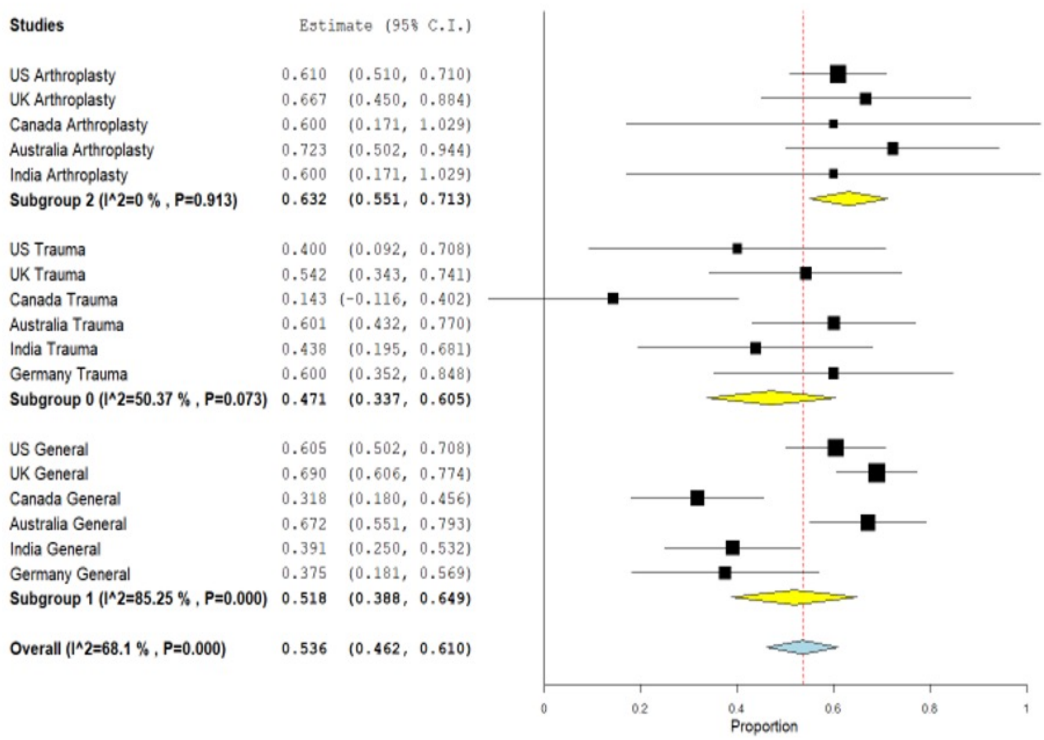

Figure 4: Proportions Preferring THA in the United States and Selected Countries
This figure displays the proportions with 95% confidence intervals (CI) of respondents from the United States and other selected countries who preferred THA.

the HEALTH trial reported no significant difference in unplanned revision procedures between THA and HA[5,11]. Studies analyzing function are more limited as follow up is heterogenous. The HOPE trial reported no difference in hip function, health related quality of life, reoperations, pain, and activities of daily living with an endpoint of 2 years[13]. Consequently, there is controversy regarding the optimal treatment option, and limited research surveying current practice patterns.

The BHA Project, encompassing 2,500+ respondents from 76 nations, illuminates insights into geriatric DFNFs. Notably, hospital-based practice substantially boosts THA preference by 1.7-fold, translating to one additional THA per seven fractures ($p<0.001$). Subgroup analyses exhibit a notable impact of hospital-based environments on specific subspecialties, increasing THA utilization by up to 2.5 times ($p=0.006$). Regression analysis reveals a three-fold variation in THA likelihood across practice types and subspecialties ($p<0.001$). Arthroplasty surgeons consistently favour THA across regions. Arthroplasty specialization increases THA usage by 23.3% ($p<0.001$), equating to one more THA per four fractures compared to traumatologists ($p<0.001$). Adjusted models demonstrate Canadian respondents were less inclined to perform THA, indicating one less THA performed per ten cases similar to the findings reported by Tohidi et al.[14]. On the contrary, respondents from the UK and Australia demonstrated an increased likelihood of THA, performing an additional THA in every five cases ($p<0.001$). Other nations exhibited comparable THA utilization rates.

Implications & Factors Influencing Variation in Surgical Decision-making

Findings suggest potential expansion of THA indications with notable variations across subspecialties and practice settings. Recent trials (e.g HEALTH Trial[5]) hint at improved post-arthroplasty outcomes, potentially expanding THA indications[13,15]. Variations in THA utilization across subspecialties and practice settings might relate to diverse patient and surgeon factors not analyzed in this study. Tohidi et al. reported surgeon volume of THA procedure in the 365 prior to surgery as the strongest predictor THA preference along with patient factors such as younger age, male sex, and diagnosis of rheumatoid arthritis[16]. Extensive survey studies are crucial for understanding how practice factors influence THA utilization[14]. This study demonstrates that hospital-based surgeons consistently demonstate higher inclincation towards THA (OR 1.68, $p=0.001$) across various subspecialities, even among non-arthroplasty specialists like sports surgeons. The increase in THA utilization in hospital-based settings may be attributed to enhanced protocols, perioperative care, and increased availability of resources that is present in hospital based settings. Conducting comprehensive outcome studies and randomized subgroup analyses can provide more precise estimates.

Several factors contribute to the wide variability in surgical decision-making for geriatric DFNF. Surgeon preference for THA can be driven by familiarity and comfort with the procedure, likely influenced by established habits or perceived efficiency[14]. Additionally, the distribution of patients allocated among subspecialities within hospital systems can lead to homogenous case mix, further influencing surgical decision making[14]. Surgeons who routinely perform THA may likely favor THA and similarly those with limited experience with THA may have bias towards HA. Educational training, experience, and initiatives also plays a substantial role in current practice[16,17]. Resource availability- such as operating room space, staff, and prosthesis availability- can also influence procedural choices[18-20]. Other considerations include perceived lower complication rates with THA, varied approach preferences, intraoperative assessment abilities and the capacity to handle adverse events with either procedure[14,21-26]. While much of the current literature investigates patient specific characteristics in relation to outcomes, this study highlights the importance of integrating and potentially adjusting for surgeon specific factors such as practice type and location.

Amidst the controversy between THA and HA, diverse interpretations of the available literature further complicate decision making. As Hubruck et al. noted, while the majority of global hip fractures occur in Asia, most of the evidence forming guidelines come from Western studies[27]. These complexities underscore the necessity for ongoing, high-quality research to navigate surgical decisions in geriatric DFNF. This study highlights the importance of obtaining accurate global data to analyze treatment variations and associated factors such as practice type and subspeciality. This data can assist with advancing future study methodologies to tailor evidence to various subspecialties, geographic regions, and practice settings.

Limitations & Future Directions

While our survey addressed the clinical scenario of geriatric DFNF, numerous unaccounted variables could influence surgeons' choices beyond the study's scope. Factors such as preoperative patient condition, hematological parameters, presentation timing, operating room logistics, staffing, and specific hospital protocols are vital considerations that were not fully captured.

Although our survey noted surgeons' anticipated timing for surgery, a comprehensive analysis linking this information to arthroplasty choices will be a focus of future investigations.

It's essential to recognize that our study had a global reach, predominantly capturing responses from high-income or upper-middle-income countries per the World Health Organization's classification. However, the data from low-income countries were limited, and there might have been selective reporting in lower-middle-income countries. Additionally, some upper-middle-income countries might have been underrepresented due to surgeons' varying engagement in continuing medical education.

Future surveys should incentivize responses to bridge these gaps and contribute to more informed surgical decision-making across all global clinical contexts. This study demonstrated management preferences are dependent on practice setting. Many current guidelines are formed from interpretation of randomized controlled trials of conducted in large academic hospitals, which may not be representative for those practicing in smaller community based private practices. Future trials should acknowledge these practice differences. Addressing these gaps is crucial for enhancing surgical choices and optimizing outcomes, and engaging surgeons through survey practices before trial enrollment could be beneficial. Hence, survey-based and trial-based studies are imperative for advancing orthopedics in diverse clinical settings worldwide. Additional studies surrounding surgical management preferences should be focused to encompass surgical populations not commonly represented whether that be in low resource populations or private practice communities.

Conclusion

A nearly three-fold discrepancy exists in the propensity to prefer THA for geriatric DFNF across subspecialties and practice environments. Extensive global surveys and future large randomized controlled trials can help understand these differences' underlying factors. These efforts should consider randomization strategies for stratified analyses, explaining heterogeneous estimates from previous data, and enhancing training, education, and quality improvement initiatives for specific practice systems.

Declarations

Funding

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Financial Interests

The authors declare they have no financial interest in this manuscript. Jan Szatkowski and Derek Moore have ownership (stock) in Orthobullets.com. No honoraria unrelated to this project or any content in this manuscript was received.

Non-Financial Interests

DM is the Chief Executive Officer and Founder of OrthoBullets. JS is a managing editor of OrthoBullets.

Proper Credit

Proper credit has been given to all cited sources, ensuring transparency and academic integrity.

Ethics Approval

We confirm that we meticulously adhered to all ethical requirements, particularly in the proprietary utilization of data collected by Orthobullets. The investigation was conducted at Orthobullets in Santa Barbara, California, USA, and Ontario, Canada.

Informed Consent

Informed consent was diligently obtained from all study participants, entirely in compliance with ethical standards.

Consent for Publication

All authors wholeheartedly endorse the publication of this manuscript in the Journal of Orthopedics and Orthopedic Surgery.

Availability of Data and Materials

We are ready to provide the data used in this study or conduct additional analyses when you'd like.

Code Availability

This study's software applications or custom code are accessible upon request.

Authors' Contributions

All authors contributed significantly to this work. The survey development, research project design, and manuscript preparation were collaborative efforts involving all authors. Jan Szatkowski, Derek Moore, and Shaun Patel performed material preparation and data collection. C.J. Foote conducted the analyses, regularly consulting and editing with Jan Szatkowski. The initial manuscript draft was composed by C.J. Foote and edited by Chirag Soni. All authors offering valuable insights on earlier versions. The final manuscript underwent review and approval by all authors.

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Supplementary Material

GRADE Report (Table 1)

Principal Surgical/Clinical Question:

What factors contribute to variations in Total Hip Arthroplasty (THA) utilization rates among orthopedic surgeons addressing geriatric displaced femoral neck fractures, considering practice environments, subspecialties, and geographic influences?

Setting: There are various practices, subspecialty, and geographic contexts that are considered in this study.

Specific Key Questions Important to Orthopaedic Surgeons and Researchers

A. What are the prevalence rates of Total Hip Arthroplasty (THA) utilization among orthopaedic surgeons specifically addressing geriatric displaced femoral neck fractures?

B. Does the prevalence of THA for geriatric displaced femoral neck fractures significantly differ between hospital-based and private practice environments among orthopaedic surgeons, and if so, what is the extent of this difference?

C. Is there significant variation in the prevalence of THA utilization across different subspecialties within orthopaedic surgery for geriatric displaced femoral neck fractures, and what is this variance?

D. To what extent do hospital-based influences impact THA utilization rates across various subspecialties within orthopaedic surgery?

E. Among diverse practice environments and subspecialties, is there a notable gradient variation in THA preferences consistent with anticipated trends related to surgeon volume and existing literature assessments?

F. Are discernible differences in THA utilization rates influenced by country, regional, or geographic considerations among orthopaedic surgeons specializing in geriatric displaced femoral neck fractures?

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A. What are the prevalence rates of Total Hip Arthroplasty (THA) utilization among orthopaedic surgeons specifically addressing geriatric displaced femoral neck fractures?

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	orthopaedic surgeons believe that total hip arthroplasty (THA)	hemiarthroplasty (HA) and other surgical options are being predominantly utilized to	Relative (95% CI)	Absolute (95% CI)		
Overall Total Hip Arthroplasty Utilization Rate												
1		serious[a]	not serious	serious[b]	not serious				**48.7%**[c, d] (39.9 to 57.5%)		-	CRITICAL

CI: confidence interval; **OR:** odds ratio

Explanations

a. Risk of bias: The survey is one of the most comprehensive endeavours in orthopaedic surgery, boasting global participation from 76 countries across various continents. Although the survey amassed a significant response from over 2500 participants, it's important to note that the pool of respondents was constrained to orthopaedic surgeons with computer access, engagement with the educational website, and the requisite time and resources to complete the survey. Consequently, the selection process might have led to a potential underrepresentation of senior orthopaedic surgeons and those practicing in Low- and Middle-Income Countries (LMICs).

b. Indirectness: While the estimate provided is robust, it predominantly reflects data from high-income and high-middle-income countries. Caution is advised when extrapolating these findings to lower-middle and low-income countries, aligning with guidance from authoritative bodies such as the World Health Organization (WHO), the World Bank, and the Lancet Commission for Global Surgery. Additionally, given the substantial variability observed among orthopedic subspecialties and practice environments, nuanced estimates tailored to specific subspecialties, practice types, and geographic regions are preferred for more accurate applications, even though these estimates might be less robust and precise.

c. The total hip arthroplasty (THA) utilization rates across various subgroups were comparable: the overall rate stood at 51.5% (95% CI 49.6 to 53.4%), with 52.3% (95% CI 45.2 to 59.3%) among those with subspecialty information and 48.7% (95% CI 39.9 to 57.5%) within the primary sample, focusing on practice environment specifics. The emphasis on the latter rate (48.7%) was due to the study's primary focus on practice-type distinctions. These differences across groups did not exhibit significant disparities (p=0.81).

d. Risk of Bias for Practice Type Analysis: In assessing the representativeness of the subgroup analysis contrasting hospital-based versus private practice surgeons, our study included a meta-analysis encompassing respondents from various practice types, such as large academic hospitals, sizeable hospital settings, and private practices. The comparison with the overall estimate revealed similar effect sizes, supported by statistical tests indicating a lack of heterogeneity. However, it's crucial to note that the limitations inherent in the prevailing estimate also pertain to this subgroup analysis. The sample inadequately represents lower-income countries and specific practice environments, which limits the generalizability of these findings.

B. Does the prevalence of THA for geriatric displaced femoral neck fractures significantly differ between hospital-based and private practice environments among orthopaedic surgeons, and if so, what is the extent of this difference?

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	we believe that hospital-based systems	private practice has different rates of THA utilization	Relative (95% CI)	Absolute (95% CI)		
Assessment of THA Utilization Rates: Hospital-based Systems versus Private Practice Comparison												
1		serious[a]	serious[b]	serious[c]	not serious				**OR 1.69** (1.31 to 2.17)	**2 fewer per 1,000** (from 2 fewer to 1 fewer)	-	CRITICAL

CI: confidence interval; **OR:** odds ratio

Explanations

a. Risk of Bias for Practice Type Evaluation: The relationship between hospital-based practice and increased THA utilization, while potentially significant across various contexts, presents challenges due to the nuanced influence of hospital systems on surgeons' preferences. Educational structures, hospital types, and interdisciplinary dynamics contribute to variability. Validating this relationship in diverse settings may offer insights into the extent of THA preference in geriatric displaced femoral neck fractures. Hence, we consider this association 'severe' due to its multifaceted and context-dependent nature.

b. Assessment of Practice Type Inconsistency: We identified a potential bias in evaluating practice type due to variations across subspecialties and geographic regions. Considerable influence is expected among specific subspecialties, such as sports surgeons, where hospital-based settings might notably impact THA utilization owing to specialized education and practice. Other subspecialties, less involved in THA procedures, might showcase a more pronounced impact on hospital systems due to interdisciplinary settings fostering arthroplasty education and surgical support.

c. Indirectness of Practice Type Evaluation: The application of the general estimate might lack direct relevance in specific contexts due to multiple influencing factors. For instance, the forecast and required sample sizes might significantly differ in regions with varying subspecialty proportions or lower interdisciplinary interaction, especially where arthroplasty surgeons are predominant in managing fractures.

C. Is there significant variation in the prevalence of THA utilization across different subspecialties within orthopaedic surgery for geriatric displaced femoral neck fractures, and what is this variance?

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	we believe that there are higher THA utilization rates among arthroplasty surgeons	other subspecialties	Relative (95% CI)	Absolute (95% CI)		
Arthroplasty Specialists versus Other Subspecialty: Estimate of Differences in the Percentage Utilizing THA (Raw Analysis)												
1		very serious[a]	serious	serious[b]	not serious				**12.7%** (5.1 to 20.3)	**127 more per 1,000** (from 51 more to 203 more)	-	CRITICAL
Arthroplasty Specialists versus Other Subspecialty: Estimate of Differences in the Percentage Utilizing THA (Subgroup Meta-analysis)												
1		serious[c]	serious	serious[d]	not serious				**14.3** (7.1 to 21.5)	**143 more per 1,000** (from 71 more to 215 more)	-	CRITICAL
Arthroplasty Specialists versus Other Subspecialty: Estimate of Differences in the Percentage Utilizing THA (Bayesian Multivariable Regression Analysis: Adjustment for Geographic Region)												
1		not serious	serious[e]	serious	not serious				**21.4%** (18.3 to 24.5)	**214 more per 1,000** (from 183 more to 245 more)	-	CRITICAL
Comparison of Arthroplasty Specialists vs. Other Subspecialties: Odds Estimate of THA Utilization Percentage Difference (Bayesian Multivariable Regression Analysis with Geographic Region Adjustment)												
1		serious[f]	serious	serious	not serious				**OR 2.39** (1.54 to 3.70)	**214 more per 1,000** (from 245 fewer to 183 fewer)	-	CRITICAL

CI: confidence interval; **OR:** odds ratio

Explanations

a. Risk of Bias Assessment in Raw Analysis of Specialty Type Influence on THA Utilization: The unadjusted estimate anticipated higher THA use among arthroplasty specialists. However, regional disparities in the contribution of arthroplasty and non-arthroplasty subspecialties to THA rates and the influence of geography and subspecialty might challenge reproducibility in different samples without adjusted estimates.

b. Inconsistency in Specialty Evaluation: While non-arthroplasty surgeons consistently exhibit lower THA rates than arthroplasty specialists, individual subspecialties may display varying trends, both in expected and unexpected manners.

c. Risk of Bias for Subgroup Meta-analysis for Arthroplasty versus Non-Arthroplasty Surgeons: The subgroup meta-analysis offers a more equitable comparison by assigning appropriate weight to sports surgeons, although they are underrepresented due to their divergence from typical practice scope. This amplifies the estimate since sports surgeons generally exhibit a lower THA rate. Potential biases across geographic regions and other unadjusted factors remain pertinent.

d. Inconsistency of Specialty Evaluation (Subgroup Meta-analysis): While non-arthroplasty surgeons generally exhibit considerably lower THA rates than arthroplasty specialists, individual subspecialties in this category may demonstrate predictable and unpredictable variations. The subgroup meta-analysis provides a better representation of sports surgeons, yet distinct estimates between specialties still exhibit variability, as anticipated in future surveys.

e. Considerations for Bayesian Multivariable Regression in Arthroplasty versus Non-Arthroplasty Surgeons: The Bayesian analysis accounted for imputed data to include sports surgeons and adjusted for geographic regions. The estimate shifted from 14.3% to 21.4%, revealing THA rate disparities among subspecialties. Adjusting for practice type led to a 19.8% increase, offering broader relevance yet retaining some variation. While moderate bias risk exists, interpretation caution is advised due to potential responder bias and subspecialty variability. In the principal Bayesian model with American traumatologists as the reference group, arthroplasty surgeons showed a 22.4% higher THA rate.

f. Considerations for the Adjusted Odds Estimate between Arthroplasty and Non-Arthroplasty Surgeons: Regarding the odds estimates for arthroplasty versus non-arthroplasty orthopedic surgeons, the raw estimate of 1.67 is noted in the main text but isn't formally included in the GRADE evaluation. This estimate, subject to biases due to varied estimates across regions and practice types, is minimized by underrepresented groups' contributions. The adjusted estimate, derived from Bayesian regression and presented as an odds estimate of 2.39 (95% CI 1.54-3.7, p<0.001) using frequentist statistics, aligns closely with Bayesian modelling. However, this adjusted estimate may still be influenced by unaccounted covariates, posing potential bias and introducing inconsistency and indirectness, particularly in specific subspecialty and practice environment comparisons.

D. To what extent do hospital-based influences impact THA utilization rates across various subspecialties within orthopaedic surgery?

E. Among diverse practice environments and subspecialties, is there a notable gradient variation in THA preferences consistent with anticipated trends related to surgeon volume and existing literature assessments?

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	we believe that non-arthroplasty surgeons in private practice have different THA rates	Arthroplasty surgeons in hospital-based environments	Relative (95% CI)	Absolute (95% CI)		
Comparative Odds of Total Hip Arthroplasty between Hospital-based Arthroplasty Surgeons and Private Practice Non-Arthroplasty Surgeons (Multivariable Logistic Regression Model)*												
1		serious[a]	not serious	serious[b]	not serious	strong association dose-response gradient			**OR 3.13** (1.76 to 5.57)	**277 more per 1,000** (from 137 more to 416 more)	-	
Comparative Odds of Total Hip Arthroplasty between Hospital-based Arthroplasty Surgeons and Private Practice Non-Arthroplasty Surgeons (Raw Estimate)												
1		very serious[c]	very serious	serious	not serious	very strong association dose-response gradient			**OR 5.45** (2.09 to 14.20)	**400 more per 1,000** (from 199 more to 601 more)	-	

CI: confidence interval; **OR:** odds ratio

** Please refer to the marginal THA rates in the main text, derived from the multivariable logistic regression model, offering nuanced insights across diverse specialties and practice environments. The GRADE table estimates above provide odds differences at the model's extremes (first estimate) and within various practice types and subspecialties, reflecting a gradient of increasing THA utilization (second estimate).*

Explanations

a. Risk of Bias in Odds of THA for Geriatric Displaced Femoral Neck Fractures: Despite adjusting for the interaction between specialty and practice environment, indicating increasing THA rates with higher hospital-based and arthroplasty specialization, estimates remain influenced by geographic variations, particularly in lower-income countries, creating a potential representation gap. Notably, high-income countries like the United States exhibit significant differences, reflecting distinct trends in arthroplasty units within large hospitals.

b. Indirectness in Odds Estimate from Logistic Regression Model: Grouping arthroplasty and non-arthroplasty encompasses various orthopaedic specialties, resulting in a robust yet generalized estimate that may mask nuanced differences among individual subspecialties.

c. Risk of Bias, Inconsistency, and Indirectness Evaluation in Academic Arthroplasty Hospital-Based vs. Private Practice Sports Surgeons Comparison: Limited sample size within subgroups and the narrow focus of comparison, primarily involving sports surgeons from high-income countries could introduce sample bias and inconsistency across arthroplasty and specific sports specialties in certain regions. Without accounting for additional factors, bias is a concern, and the estimate may not be directly applicable to sports surgeons globally, indicating a need for more comprehensive data.

F. Are discernible differences in THA utilization rates influenced by country, regional, or geographic considerations among orthopaedic surgeons specializing in geriatric displaced femoral neck fractures?

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	we believe that there is country variability in the THA rate such that US surgeons	those in other countries differ concerning THA	Relative (95% CI)	Absolute (95% CI)		
THA Rates when Comparing US and Non-US Surgeons (Raw Analysis)												
1		very serious[a]	serious[b]	serious[c]	not serious				**13.6** (7.8 to 19.3)	**136 more per 1,000** (from 78 more to 193 more)	-	CRITICAL
THA Rates when Comparing the United States and United Kingdom (Raw Analysis)												
1		very serious[d]	serious[e]	serious	not serious				**29.3** (21.4 to 37.2)	**293 more per 1,000** (from 214 more to 372 more)	-	CRITICAL
Likelihood of Performing THA in the United States versus the United Kingdom (Raw Analysis)												
1		very serious[f]	serious	serious[g]	not serious				**OR 3.40** (2.35 to 4.95)	**293 more per 1,000** (from 214 more to 372 more)	-	CRITICAL
THA Rates when Comparing US and Non-US Surgeons (Bayesian Adjusted Analysis)												
1		very serious[h]	very serious	very serious[i]	not serious				**6.5%** (5.6 to 7.4)	**65 more per 1,000** (from 56 more to 74 more)	-	IMPORTANT
Likelihood of Performing THA in the United States versus Other Countries (Bayesian Adjusted Analysis)												
1		very serious[j]	very serious	very serious	not serious				**OR 1.31** (1.30 to 1.32)	**65 more per 1,000** (from 56 more to 74 more)	-	IMPORTANT
THA Rates when Comparing the US and United Kingdom (Bayesian Adjusted Analysis)												
1		serious[k]	serious	serious[l]	not serious				**17.6%** (16.5 to 18.7)	**176 more per 1,000** (from 165 more to 187 more)	-	CRITICAL
Likelihood of Performing THA in the United States versus the United Kingdom (Bayesian Adjusted Analysis)												
1		serious[m]	serious[n]	serious[o]	not serious				**OR 2.05** (2.02 to 2.07)	**176 more per 1,000** (from 165 more to 187 more)	-	CRITICAL

CI: confidence interval; **OR:** odds ratio

Explanations

a. Risk of Bias: The comparison between US and non-US surgeons shows a notable discrepancy. However, the method might favour certain countries, providing limited influence on the non-US estimate. Additionally, confounding factors like the proportions of arthroplasty or hospital-based surgeons weren't accounted for in the analysis. Nevertheless, this estimate reflects differences in subspecialization representation and possible variations in surgeon proportions across countries.

b. Inconsistency: Specific comparisons between the United States and other countries have exhibited variation within this study. Thus, the general estimate might be an oversimplification. Future studies should consider this variability based on the countries included and compared with the United States, considering the respondent pool's proportions for each country.

c. Indirectness: Due to significant heterogeneity in estimates between the US and other countries, applying this comparison to specific country analyses is highly indirect.

d. Risk of Bias in Comparing THA Rates between Orthopaedic Surgeons in the United Kingdom and the United States (Raw Analysis): The differences reported in THA rates are influenced by patient characteristics, surgeon practices, subspecialization, and the distinction between hospital and private practice settings. Notably, 37.7% of American orthopaedic surgeons worked in large hospital settings, whereas 100% operated within large NHS hospitals in the United Kingdom, potentially impacting THA rates. While the proportions of arthroplasty surgeons were similar (11.4% in the UK and 10.8% in the US), the environment in the UK seems more conducive to arthroplasty. This might introduce bias, yet it provides a realistic view of current trends. The adjustments made for subspecialty and other factors may only partially account for the complex dynamics of different healthcare systems.

e. Inconsistency and Indirectness in Comparing THA Rates between Orthopaedic Surgeons in the United Kingdom and the United States (Raw Analysis): While the estimate for the United Kingdom appears relatively robust, it may be affected by regional variations within the UK and the US, differences in respondent demographics, varying proportions of subspecialties, and hospital-based practices among different groups within the US. These disparities could slightly alter the estimates and might limit the direct application of this estimate to specific contexts. Overall, the estimate from the United Kingdom appears more consistent due to its widespread NHS hospital-based healthcare system for orthopaedic surgical care.

f. Please see the explanation above for UK versus US THA rates. These apply here.

g. Consistency and Indirectness in Fixed Effects Models for THA Rate Estimation (Very Serious): Fixed effects models aim to explain outcome variations by adding independent covariates, presuming independence without considering clustering. While striving for consistency, these models might fail to address heterogeneity beyond their capability or assumptions. Limitations Impacting Estimation 1. Generalized Estimation: Aggregated country data obscures nuanced differences, leading to a generalized understanding of THA rate disparities across diverse nations. 2. Incomplete Data Representation: Fixed-effect models cannot capture intricate clustering patterns and complex interactions within the dataset. 3. Sample Size Requirement: Comprehensive assessment demands larger sample sizes for evaluating diverse covariate interactions, which are presently insufficient. This approach may yield consistent estimations in future studies considering these limitations.

h. Risk of Bias and Caution with Interpreting the Estimate for the Difference in the THA Rate between the United States and Other Countries: Issues 1. Aggregated Estimate: The US versus non-US THA rate difference is an oversimplified aggregation of diverse countries, leading to a generalized estimate. 2. Complex Clustering: Fixed-effect models cannot fully capture complexities stemming from clustering, not solely at the intercept but throughout the data structure. 3. Interaction Complexity: Interactions among covariates and unaccounted variables in the model add complexity, requiring larger sample sizes for comprehensive evaluation.

i. Indirectness and Model Complexity (Very Severe for "Adjusted" United States versus "Other Countries" for Differences in THA Utilization Rates) The indirectness is pronounced due to the model's lack of sophistication in addressing data complexity. Larger sample sizes are necessary to accommodate the intricacies of various influencing factors and their impact on surgeon decision-making, particularly in altering THA rates. Conclusion Fixed effects models, while seeking consistency, demonstrate limitations in comprehensively understanding THA rate disparities. These limitations encompass generalized estimations, incomplete data representations, and the need for larger sample sizes to evaluate diverse covariate interactions adequately. Recommendations Future studies should consider employing more sophisticated models capable of addressing data complexities and accommodating larger sample sizes to comprehensively assess the factors influencing THA rates and surgeon decision-making.

j. Odds Estimation for THA between the United States and Other Countries: A Cautionary Note on Fixed Effects Models (Result: Risk of Bias = Very serious; Predicted Inconsistency in Future Studies = Very serious; Indirectness = Very Serious) Implications The odds estimation for Total Hip Arthroplasty (THA) between the United States and other countries, utilizing fixed-effects models, simplifies a highly intricate dataset, mirroring the limitations highlighted in the previous analysis of THA rate differences. This model's use of fixed effects oversimplifies the nuanced variations across countries, neglects intricate clustering patterns within the data, and requires larger sample sizes to evaluate covariate interactions comprehensively. Addressing these limitations warrants the adoption of hierarchical models or an increase in sample sizes. These approaches would offer a more nuanced understanding of THA rate disparities and the complex interplay of covariates within diverse country contexts

k. Risk of Bias: Serious to Very Serious The model's adjustments account for the United Kingdom separately, reducing over-aggregation with the "Non-United States" category. However, unadjusted variation in hospital-based covariate correction poses a risk of bias. The model's overall estimates might not precisely apply to specific comparisons, such as private practice in the US versus hospital-based care in the UK.

l. Consistency: Serious Consideration: The model's general adjustment may lack precision for specific comparisons between practice types and subspecialties across countries, leading to inconsistency in estimates. Indirectness: Serious to Very Serious Challenges: While the model corrects for subspecialty differences and proportional representation, it fails to address nuanced variations within practice types across countries. Applying the estimate to the UK without refinement would be grossly inappropriate.

m. Risk of Bias, Probable Future Inconsistency, and Indirectness in Bayesian Adjusted Odds Estimate for THA (United States versus United Kingdom) (Section 1) Risk of Bias: Moderate to Serious The revised odds estimate indicates a 2-fold increase in THA odds in the United Kingdom versus the United States post-adjustment for orthopaedic subspecialties. Similar limitations observed in generating THA rate differences between both countries persist here. While seemingly robust, the odds estimate still faces biases related to data complexity and the model's dependence on the baseline rate.

n. (Section 2) Probable Future Inconsistency: Moderate Consideration: Though seemingly more independent of THA baseline rates, the odds estimate might offer robustness in reporting. However, the complex data nature described earlier challenges consistent reporting and external validation in other datasets, posing a risk of future inconsistencies.

o. (Section 3) Indirectness: Moderate to Serious Data complexity hampers consistent reporting and external reproducibility. The odds estimate's dependence on intricate data nuances and the model's limitations in capturing nuanced variations within practice types across countries raise concerns regarding indirectness.

Table 2: Bayesian Estimates of THA Utilization Rates

This table presents Bayesian estimates of Total Hip Arthroplasty (THA) utilization rates concerning geriatric displaced femoral neck fractures. The 'Intercept' indicates the estimated utilization rate among orthopaedic trauma surgeons in the United States, noted at 37.4% (95% CrI 33.4 to 41.3%). The 'Country' parameters signify the percentage change in THA utilization compared to the United States, while the 'Subspecialty' parameters indicate variations relative to orthopaedic trauma. Mode and Mean estimates and associated credible intervals illustrate potential differences in THA preferences across various countries and subspecialties.

Parameter	Posterior		95% Credible Interval Parameter	
	Mode	Mean	Lower Bound	Upper Bound
(Intercept)	37.4	37.4	33.4	41.3
Country				
US	.[d]	.[d]	.[d]	.[d]
Canada	-10.1	-10.1	-14.7	-5.6
India	1.1	1.1	-3.4	5.7
Germany	6.5	6.5	2.0	11.1
Australia	16.9	16.9	12.3	21.5
UK	17.5	17.5	13.0	22.1
Subspecialty				
Trauma	.[d]	.[d]	.[d]	.[d]
Sports	-2.3	-2.3	-6.0	1.5
General	5.0	5.0	1.3	8.8
Arthroplasty	22.4	22.4	18.7	26.1

a. Dependent Variable: Percentage of Surgeons Utilizing THA for Geriatric Displaced Femoral Neck Fractures.

b. Model: The model consists of several components:

• Intercept: Represents the baseline THA rate among American traumatologists.

• Geographic Covariate: Set to the United States, comparing THA rates between the U.S. and a specific country, which serves as the comparator (i.e., country-specific estimate).

• Specialty Parameter: Focuses on orthopedic traumatology subspecialization, examining its influence on THA utilization.

c. Priors: Utilizes standard reference priors, acting as non-informative probability distributions in Bayesian analysis.

d. Specified reference categories:

• American traumatologists serve as the baseline for the THA rate.

• The United States represents the geographic covariate.

• Orthopedic traumatology subspecialization acts as the reference for the specialty parameter.

Note: This setup utilizes a Bayesian hierarchical model to assess how different countries and subspecialties within orthopedic surgery affect the utilization of THA for geriatric displaced femoral neck fractures, using the THA rate among American traumatologists as the baseline. Negative values in this context represent differences indicating THA rates lower than the intercepted rate.

Appendix 1

Additional Background & Study Rationale

The global demographic landscape is rapidly evolving, marked by a projected twofold increase in the population aged 65 or older by 2030 compared to 2019 [1]. This shift towards an aging population is accompanied by a significant rise in disabilities among older individuals, particularly physical limitations [2]. Hip fractures, specifically displaced femoral neck fractures, have shown a remarkable sevenfold increase since 1990, surpassing earlier predictions [3-6]. Data from the World Health Organization (WHO) and the United Nations (UN) highlights two noteworthy trends: a substantial increase in the proportion of individuals aged 65 and older and a significant extension of disability periods among geriatric populations [7].

Despite this growing aging demographic, determining the optimal surgical management for hip fractures, especially significantly displaced femoral neck fractures in patients over 60, remains a challenge [8]. While clinical trials and meta-analyses lean towards advocating arthroplasty as the preferred approach, the debate continues regarding the relative efficacy of total hip arthroplasty (THA) versus hemiarthroplasty (HA) [9]. The impact of surgeon- and practice-related factors on the global selection of arthroplasty prostheses remains ambiguous [10].

For several reasons, understanding orthopedic surgeons' preferences for THA in displaced femoral neck fractures among older patients holds pivotal significance. Firstly, obtaining accurate global data on the determinants guiding surgical decision-making for this prevalent fracture type is crucial. Secondly, global reporting offers insights into the variations of these determinants across diverse geographical regions. Lastly, this data is the cornerstone for advancing randomized trial methodologies tailoring evidence to various subspecialties, locales, and practice settings. Moreover, it facilitates innovative trial designs by integrating and adjusting "higher-order factors" beyond patient characteristics for context-specific outcomes.

Study Significance

As part of the Bullet Health Analysis series, this survey responds to the pressing need for comprehensive global insights into displaced femoral neck fractures. Our primary aim is to furnish precise estimates, supported by 95% confidence intervals, delineating surgeon preferences for total hip arthroplasty (THA) in geriatric displaced femoral neck fractures. Our analyses meticulously stratify these preferences across various subspecialties and practice environments, offering nuanced insights into the likelihood of THA selection within diverse settings for each subspecialty. This series is a testament to the extraordinary efforts of the Orthobullets team, which is instrumental in gathering global surgical decision-making data, fostering a data revolution in worldwide reporting, and guiding prospective extensive international outcome studies.

Radiographs Provided with Clinical Case Preceding the Survey

Figure 1a Appendix: This anteroposterior radiograph illustrates the clinical scenario of a 76-year-old female smoker who experienced a mechanical fall. She was an active community ambulator and had a history of ambulation. These radiographs
were provided before surveying geriatric displaced femoral neck fractures.

Figure 1b Appendix: This dedicated right hip anteroposterior radiograph was included in the clinical case provided to respondents before the survey for reference.

Figure 1c Appendix: Additional cross-table lateral radiographs were included within the clinical case for respondents' reference before the survey. This image allowed surgeons to evaluate the tilt of the femoral neck and head in the sagittal plane.

Figure 1d Appendix: This dedicated right hip anteroposterior radiograph was included in the clinical case following poll submission by respondents.

Survey Questions

1. **What additional imaging studies would you obtain to guide treatment?**
    a. None - Current radiographs are sufficient
    b. Additional x-rays (e.g. full-length femur x-rays)
    c. Hip CT

   d. Hip MRI
   e. Additional x-rays + Hip CT
   f. Additional x-rays + Hip MRI
   g. Hip CT + Hip MRI
   h. Additional x-rays + Hip CT + Hip MRI
   i. Outside my area of expertise

2. **How would you manage this injury?**
   a. Nonoperative
   b. Operative
   c. Outside my area of expertise

3. **If you choose Operative management, assuming the patient arrived in the ER at 5PM, with their last full meal at 2PM, and is medically optimized, when would you perform Operative management?**
   a. I would not choose Operative management
   b. Same night (within 6 hours of arrival to ER)
   c. Following morning first case before elective cases/clinic (12-24 hours)
   d. Follow day after elective cases/clinic (24 – 32 hours)
   e. When convenient within 3 days from admission
   f. When convenient within 5 days from admission
   g. Outside my area of expertise – best if I don't vote

4. **If you choose Operative management, what surgical technique would you use?**
   a. I would not choose Operative management
   b. Open reduction internal fixation (ORIF)
   c. Hemiarthroplasty
   d. Total hip arthroplasty (THA)
   e. Outside my area of expertise – best if I don't vote

5. **If you choose Open reduction internal fixation (ORIF), what fixation construct would you use?**
   a. I would not choose ORIF
   b. Cannulated screws only
   c. Dynamic/sliding hip screw
   d. Cephalomedullar nail
   e. Proximal Femoral Locking Plate
   f. Outside my area of expertise – best if I don't vote

6. **If you choose Hemiarthroplasty, what surgical approach would you use?**
   a. I would not choose Hemiarthroplasty
   b. Direct anterior (Smith-Petersen)
   c. Anterolateral (Watson-Jones)
   d. Direct lateral (Hardinge)
   e. Posterolateral
   f. Outside my area of expertise – best if I don't vote

7. **If you choose Hemiarthroplasty, how would you address femoral reconstruction?**
   a. I would not choose Hemiarthroplasty
   b. Uncemented femoral stem
   c. Cemented femoral stem
   d. Outside my area of expertise – best if I don't vote

8. **If you choose Hemiarthroplasty, what kind of femoral head would you use?**
   a. I would not choose Hemiarthroplasty
   b. Uni/monopolar
   c. Bipolar
   d. Outside my area of expertise – best if I don't vote

9. **If you choose Total hip arthroplasty (THA), what surgical approach would you use?**
    a. I would not choose THA
    b. Direct anterior
    c. Anterolateral
    d. Direct Lateral
    e. Posterolateral
    f. Outside my area of expertise – best if I don't vote
10. **If you choose Total Hip Arthroplasty (THA), how would you address femoral reconstruction?**
    a. I would not choose THA
    b. Uncemented Femoral Stem
    c. Cemented Femoral Stem
    d. Outside my area of expertise – best if I don't vote
11. **If you choose Total Hip Arthroplasty (THA), what bearing articulation would you use?**
    a. I would not choose THA
    b. Metal-on-metal
    c. Metal-on-polyethylene
    d. Ceramic-on-ceramic
    e. Ceramic-on-polyethylene
    f. Dual mobility with a metal inner head
    g. Dual mobility with a ceramic inner head
    h. Outside my area of expertise – best if I don't vote
12. **If you choose Hemiarthroplasty or a Total hip arthroplasty (THA), and choose to cement the femoral stem, would you use antibiotic-laden bone cement?**
    a. I would not choose Hemiarthroplasty or THA with a cemented femoral stem
    b. Yes – I would use antibiotic-laden bone cement
    c. No – I would NOT use antibiotic laden bone cement
    d. Outside my area of expertise – best if I don't vote
13. **If you choose Hemiarthroplasty or Total hip arthroplasty (THA), for how long would you prescribe DVT prophylaxis?**
    a. I would not choose Hemiarthroplasty or Total Hip Arthroplasty
    b. I would not prescribe any DVT prophylaxis
    c. 2 weeks
    d. 4 weeks
    e. 6 weeks
    f. >6 weeks
    g. Outside my area of expertise – best if I don't vote

Methods

Acknowledgment of AI Utilization

This paper utilized AI for rectification of grammatical errors. AI did not generate new content, analyze data, or interpret findings [11,12].

Results

Respondent Characteristics

Among the 2606 participants as of June 2023, 2392 (91.8%) provided subspecialization details during registration, constituting approximately 62.9% to 74.8% of survey viewers. Among these respondents, 615 (25.7%) specified a subspecialization, while 1752 (74.3%) were categorized as generalists. Out of the total, 1056 (44.7%) disclosed their practice environments, which were distributed across academic hospitals (12.1%), non-university affiliated hospitals (34.3%), or private practices (53.6%).

Impact of Practice Environment on Total Hip Arthroplasty (THA)

The weighted percentage of respondents favouring THA within the subgroup reporting their practice environment was 48.7% (95% CI 39.9

to 57.5%), suggesting representation of the entire cohort (51.5%, 95% CI 49.6 to 53.4%). Among respondents in large hospital systems, THA preference was 53.3% (95% CI 49.6 to 57.0%), while in private practice, it stood at 41.2% (95% CI 36.1 to 46.2%), indicating a difference of 13.3% (95% CI 8.0 to 18.6%, p<0.001). The comparative analysis demonstrated 1.69-fold higher odds of preferring THA among those in large hospital environments than private practice (OR 1.69, 95% CI 1.31 to 2.17, p<0.001). Figure 2 in the main text visualizes THA preferences stratified by subspecialty and further segmented by large hospital-based systems versus private practice, highlighting variations across subspecialties and practice settings.

Figure 3, a Forrest plot, also presents the meta-analytic aggregate rate of THA preference for each subspecialty within both practice environments. It's important to note that significance levels should be interpreted from comparative odds ratio estimates in Figure 2 rather than heterogeneity tests in Figure 3.

For more details on internal validity and validation analyses, please see BHA Appendix 2.

Variation in Total Hip Arthroplasty Utilization Across Subspecialties

Among respondents specifying a subspecialty (or general category), the estimated weighted percentage favouring THA was 52.3% (95% CI 45.2 to 59.3%), aligning closely with the overall respondent pool (51.5%, 95% CI 49.6 to 53.4%), confirming its representativeness. Subspecialty preferences for THA were observed as follows: arthroplasty 63.4% (95% CI 56.7 to 70.0%), trauma 53.4% (95% CI 47.2 to 59.6%), general orthopedic surgery 51.4% (95% CI 49.1 to 53.7%), and sports 40.2% (95% CI 32.6 to 47.9%) (p<0.001 for percentage differences). Arthroplasty surgeons exhibited a 12.7% higher preference for THA than other subspecialties (OR 1.67, 95% CI 1.24 to 2.26, p=0.001). However, upon regression adjustment for factors like practice type, the arthroplasty subspecialty demonstrated a 19.8% increase in THA utilization (95% CI 8.3 to 31.2%, p<0.001). A nuanced analysis highlighted stark contrasts, notably between academic arthroplasty surgeons and private sports surgeons, with academic arthroplasty surgeons being 5.4 times more inclined to perform THA (95% CI 2.09 to 14.2, p=0.001).

Regression Analysis for Subspecialty and Practice Type (Arthroplasty versus Non-Arthroplasty & Hospital versus Private Practice)

The multivariable regression analysis produced projected percentages reflecting distinct preferences for THA concerning subspecialty and practice settings (e.g., Arthroplasty/Large Hospital Setting 67.3%, Non-Arthroplasty/Large Hospital Setting 52.8%, Arthroplasty/Private Practice 52.0%, Non-Arthroplasty/Private Practice 39.6%). These differences held statistical significance (Subgroup Difference Test: p<0.001), indicating, for instance, a 3-fold difference in the likelihood of opting for THA between arthroplasty surgeons in hospitals versus non-arthroplasty surgeons in private practice (OR 3.13, 95% CI 1.96 to 5.02, p<0.001).

Geographic Impact on THA Utilization

The meta-analytic average for THA preference among respondents across selected countries stood at 49.5% (95% CI 38.2 to 60.7%, Figure 3), closely mirroring the overall cohort's preference of 51.5% (95% CI 49.6 to 53.4%, Test for THA Rate Differences Between Groups: p=0.81). Figure 3 displays THA preferences with 95% confidence intervals for the chosen countries. Subgroup analysis revealed variations in THA preference between subspecialties. Arthroplasty-trained surgeons showed minimal differences across countries (I^2=0% with p=0.91), while generalists (I^2=50.3%) and traumatologists (I^2=85.3%) exhibited substantial variability, especially compared to arthroplasty and non-arthroplasty surgeons across analyzed countries. A multivariable regression analysis, detailed in Table 1 in the Appendix section, investigated the independent association between subspecialty, geographic location (country), and the preference for THA in geriatric displaced femoral neck fractures. This analysis revealed that arthroplasty specialization was associated with a 23.3% increase in THA utilization (95% CI 10.8 to 35.7%, p<0.001) compared to traumatologists and compared to the United States, the United Kingdom and Australia demonstrated a higher frequency of THA (approximately one more THA per five cases compared to the United States, p<0.001). On average, Canada performed THA less frequently (i.e., one less THA in ten cases), while other countries did not significantly differ from the United States in THA preference.

Sensitivity Regression Analysis Excluding Sports Surgeons

The multivariable metaregression analysis results are presented in Table 'Table 1 Appendix' below, focusing on THA utilization rates for geriatric displaced femoral neck fractures. The table illustrates the percentage change in THA utilization and corresponding 95% confidence intervals for various model parameters. The 'Country' parameters exhibit the percentage change in THA utilization concerning the reference group (United States), while 'Subspecialty' parameters reflect changes relative to orthopaedic trauma. These values represent the variation in THA rates, indicating potential differences in THA preferences across different countries and subspecialties. The reference group (the intercept of the metaregression) comprises American traumatologists, denoting a THA rate of 40.0% (95% CI 19.9 to 60.1%). The model excludes sports specialization. Subsequently, a Bayesian regression with multiple imputations (20 iterations) encompassing sports subspecialization was performed. While the main text presents the Bayesian model with estimates similar to this original model for country and subspecialty covariates, it's crucial to note that the Bayesian regression analysis demonstrates greater robustness. The presentation of this initial model in the Appendix is for transparency and comparison purposes.

Table 1 Appendix: Original Frequentist Multivariable Metaregression Results

This table presents the impact of subspecialties and geographic regions on the proportion of surgeons favouring THA. It illustrates the percentage change in THA utilization and corresponding 95% confidence intervals for various model parameters. 'Country' parameters signify the alteration in THA utilization concerning the United States, while 'Subspecialty' parameters indicate changes relative to orthopaedic trauma. These values elucidate the diversity in THA preferences across different countries and subspecialties. The reference group (the intercept of the metaregression) comprises American traumatologists, reflecting a THA rate of 40.0% (95% CI 19.9 to 60.1%).

Regression Parameter	Subspecialty	Change in Percentage THA	95% Confidence Interval	p-value
Intercept[b]	Reference %	40.0%[a]	19.9 to 60.1%	<0.001[c]
	Trauma	Ref [d]		
Subspecialty	General	7.8%	-1.1 to 16.7%	0.08
	Arthroplasty	23.3%	10.8 to 35.7%	< 0.001
Country	US	Ref		
	Australia	17.9%	7.5 to 28.3%	< 0.001
	Canada	-11.9%	-24.2 to 0.5%	0.06
	Germany	6.4%	-9.6 to 22.4%	0.44
	India	-0.2%	-12.6 to 12.2%	0.97
	United Kingdom	23.4%	15.2 to 31.6%	< 0.001

a. Dependent Variable: Percentage of Surgeons Utilizing THA b. Model Composition:

- Intercept: Baseline THA rate for American traumatologists.
- Geographic Covariate: United States for comparative assessment.
- Specialty Parameter: Focus on orthopedic traumatology subspecialization. c. P-values: Reported for frequentist models (logistic regression or metaregression); not applicable in Bayesian models (see the main text for Bayesian model specifics). d. Reference Categories:
- American traumatologists are responsible for the baseline THA rate.
- The United States for the geographic covariate.
- Orthopedic traumatology subspecialization for the specialty parameter.

Note: This analysis uses a Frequentist regression model, commonly employed in orthopedic surgery studies. It assesses how different countries and orthopedic subspecialties influence THA utilization for geriatric displaced femoral neck fractures, utilizing American traumatologists' THA rate as a baseline.

Bayesian Regression Analysis: Comparison of THA Utilization Rates (Geographic Aggregation Models)

This analysis showcases outcomes from a multivariable Bayesian approach focused on examining THA utilization rates in geriatric displaced femoral neck fractures. It details percentage shifts in THA utilization and corresponding 95% credible intervals for various model parameters.

- 'Country' Parameters: Highlight alterations in THA utilization concerning the United States as the reference.
- 'Subspecialty' Parameters: Illustrate variances related to orthopedic trauma preferences.

The model's benchmark reflects American traumatologists, indicating a THA rate of 37.3% (95% CI 36.3 to 38.3%).

This Bayesian regression, incorporating multiple imputations (20 iterations) that accounted for sports subspecialization, reveals distinctive THA rates between the United States and other countries. In this Geographic Aggregation Model, other countries exhibit a 6.5% (95% CrI 5.6 to 7.4%) higher THA rate than the US.

The two models are described as follows:

1. *The Geographic Overaggregation Model* simplifies geographic parameters by grouping countries, excluding the United States. It attempts to provide insights into overall THA preferences across various regions but may overlook nuanced differences between countries with discrepant THA rates.
2. *The Geographic Targeted UK Aggregation Model* aims to segregate the United Kingdom from the overaggregated group. This model provides a more refined perspective on THA utilization rates by explicitly focusing on the United Kingdom and its distinct behaviour compared to other nations. It attempts to adjust for geography and subspecialty using available data, considering variations in subspecialty distributions across nations.

Both models offer insights into THA preferences for geriatric displaced femoral neck fractures across diverse geographic regions, albeit with different levels of granularity and consideration of distinct regional behaviours.

Sensitivity Analysis: Bayesian Model Variations

Tables 2 Appendix and 3 Appendix illustrate sensitivity analyses derived from the primary Bayesian model outlined in the main text. The first model simplifies countries into US versus non-US, while the second differentiates the US and UK, grouping other countries as 'Other.'

Initially, an oversimplified view showed a 6.5% increase in THA rates outside the US. However, individual country variations were disregarded. For example, while Canada had a lower rate, Australia and the UK exhibited higher THA rates than the US.

Upon adjustment for the orthopedic subspecialty, the UK showed a 17.6% higher THA rate, down from the raw 29.3%. Despite similar arthroplasty specialist proportions between the UK and the US, significant differences in generalist numbers affected THA rates. The US had a higher percentage of generalists, contributing to the substantial 30% raw THA rate difference from the UK.

The Bayesian model's adjustment for the UK primarily stems from differences in generalist proportions and THA rates between the US and the UK. While slight variations existed among arthroplasty surgeons, they likely had minimal impact on the model's adjustments.

Table 2 Appendix: Bayesian Multivariable Analysis - United States vs. Other Countries (*The Geographic Overaggregation Model*)

This table presents the Bayesian multivariable analysis illustrating the comparison between the United States and other countries. The model assesses the impact of subspecialties and geographic regions on surgeons' preference for THA. It displays the percentage change in THA utilization alongside corresponding 95% credible intervals for various model parameters.

This model's 'Country' parameters indicate changes in THA utilization concerning the United States, contrasting with a grouping of multiple other countries. The 'Subspecialty' parameters depict variations relative to orthopaedic trauma. These values highlight differences in THA preferences across various countries and subspecialties, considering the overaggregation of geographic data. The reference group for this model comprises American traumatologists, reflecting a THA rate of 37.3% (95% CI 36.3 to 38.3%). This model suggests a 6.5% higher THA rate in other countries than the United States (95% CrI 5.6 to 7.4%).

Parameter in the Model[b]	Posterior Mode[c]	Posterior Mean	Variance	95% Credible Interval (Lower Bound)	95% Credible Interval (Upper Bound)
Intercept	37.3%[a]	37.3%	0.0	36.3%	38.3%
United States	.d	.d	.d	.d	.d
Other Countries (Non-United States)	6.5%	6.5%	0.0	5.6%	7.4%
Subspecialty					
Trauma	.d	.d	.d	.d	.d
Sports	-2.1%	-2.1%	0.0	-3.0%	-1.1%
General	5.0%	5.0%	0.0	4.1%	6.0%
Arthroplasty	22.4%	22.4%	0.0	21.5%	23.4%

a. Dependent Variable: Percentage of Surgeons Utilizing THA for Geriatric Displaced Femoral Neck Fractures.
b. Model Composition:
- Intercept: Baseline THA rate corresponding to American traumatologists.
- Geographic Covariate: Compares THA rates between the United States and other selected countries.
- Specialty Parameter: Focuses on orthopedic traumatology subspecialization, examining its influence on THA utilization.

c. Priors: Standard reference priors utilized as non-informative probability distributions in Bayesian analysis.
d. Specified Reference Categories:
- American traumatologists serve as the baseline THA rate.
- The United States represents the geographic covariate.
- Orthopedic traumatology subspecialization acts as the specialty parameter.

Note: This model employs a Bayesian hierarchical framework to assess the impact of different countries and subspecialties within orthopedic surgery on THA utilization for geriatric displaced femoral neck fractures. American traumatologists determine the baseline THA rate.

Table 3 Appendix: Bayesian Multivariable Analysis - United States vs. United Kingdom vs. Other Countries (The Geographic Targeted UK Aggregation Model)

This table showcases how subspecialties and geographic regions impact the percentage of surgeons favouring THA. It presents the percentage change in THA utilization and corresponding 95% credible intervals for various model parameters.

The 'Country' parameters depict changes in THA utilization concerning the United States, the United Kingdom, and other countries (excluding the United Kingdom and the United States). Meanwhile, 'Subspecialty' parameters reflect variations relative to orthopedic trauma. These values illuminate differences in THA preferences across diverse countries and subspecialties.

In this analysis, American traumatologists serve as the reference group, representing a THA rate of 37.3% (95% CI 36.4 to 38.3%). The findings indicate that the United Kingdom exhibited a 17.6% (95% CrI 16.5 to 18.7%) higher THA rate than the US. Other countries showed a slight increase in the THA rate (3.7%, 95% CrI 2.8 to 4.6%).

This table provides valuable insights into comparative THA preferences among countries and subspecialties, utilizing the THA rate of American traumatologists as the baseline for comparison within the Bayesian model framework.

Parameter in the Model[b]	Posterior Mode[c]	Posterior Mean	Variance	95% Credible Interval (Lower Bound)	95% Credible Interval (Upper Bound)
Intercept	37.3[a]	37.3	0.0	36.4	38.3
United States	.d	.d	.d	.d	.d
Other Countries (Other than United States & United Kingdom)	3.7	3.7	0.0	2.8	4.6
United Kingdom	17.6	17.6	0.0	16.5	18.7
Subspecialty					
Trauma	.d	.d	.d	.d	.d
Sports	-2.1	-2.1	0.0	-3.0	-1.2
General	5.0	5.0	0.0	4.1	5.9
Arthroplasty	22.4	22.4	0.0	21.5	23.3

a. Dependent Variable: Percentage of Surgeons Utilizing THA for Geriatric Displaced Femoral Neck Fractures.
b. Model Composition:

- Intercept: Baseline THA rate for American traumatologists.
- Geographic Covariate: Comparison of THA rates between the United States, the United Kingdom, and other selected countries (non-US & non-UK).
- Specialty Parameter: Focus on orthopedic traumatology subspecialization, analyzing its impact on THA utilization.

c. Priors: Utilizes standard reference priors, serving as non-informative probability distributions in Bayesian analysis.
d. Specified Reference Categories:

- American traumatologists are the baseline THA rate.
- The United States for the geographic covariate.
- Orthopedic traumatology subspecialization for the specialty parameter.

Note: This Bayesian hierarchical model aims to assess how variations in countries and subspecialties within orthopedic surgery influence THA utilization for geriatric displaced femoral neck fractures. The THA rate of American traumatologists is the baseline for comparison within this Bayesian framework.

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10. Investigators HA (2020) Accelerated surgery versus standard care in hip fracture (HIP ATTACK): an international, randomised, controlled trial. Lancet 395 (10225):698-708. doi:10.1016/S0140-6736(20)30058-1
11. Lewis DP, Weaver D, Thorninger R, Donnelly WJ (2019) Hemiarthroplasty vs Total Hip Arthroplasty for the Management of Displaced Neck of Femur Fractures: A Systematic Review and Meta-Analysis. J Arthroplasty 34 (8):1837-1843 e1832. doi:10.1016/j.arth.2019.03.070

Appendix 2

Methods

Primary and Secondary Outcomes

Primary Outcome

- Assess the change in odds and 95% confidence intervals indicating a preference for THA between hospital-based and private practice environments.

Secondary Outcomes

- Calculate "predicted" percentages with 95% confidence intervals for respondents providing subspecialty and practice-type information, establishing their representativeness compared to the overall respondent pool.
- Perform meta-analytic comparisons of THA utilization rates between hospital-based and private practice settings for each subspecialty. Assess overall heterogeneity among percentages between subspecialties.
- Analyze the odds difference, with 95% confidence intervals, in choosing THA between arthroplasty and non-arthroplasty surgeons.
- Compute percentages and 95% confidence intervals for THA preference across multiple countries. Evaluate heterogeneity across countries in rates of surgeons favouring THA for each subspecialty.
- Conduct a multivariable regression analysis to determine the percentage difference in THA preference associated with specific subspecialties and countries. Assess independent influences of geography and subspecialty on THA utilization.

Total Hip Arthroplasty (THA) Utilization Rates (Proportion Estimation)

Proportions and their corresponding 95% confidence intervals were computed to determine the ratio of surgeons favouring Total Hip Arthroplasty (THA) across orthopedic subspecialties and practice environments. This analysis aimed to provide:

1. Refined estimates for different practice types and subspecialties (Refer to Section Two, 'Influence,' and Figure 2).
2. General estimates for selected countries (Refer to Figure 3).
3. Country-specific estimates for each subspecialty and aggregated subspecialty estimates across countries (Refer to Figure 4).

Primary Analysis

Prominent academic and non-university hospitals were amalgamated for primary analyses to facilitate meaningful comparisons with private practice settings. The primary outcome involved a comparative assessment, generating odds ratios and their respective 95% confidence intervals to evaluate THA utilization odds between private and hospital-based environments. Subgroup analyses provided odds estimates comparing major orthopedic subspecialties in hospital-based versus private practice settings. Visual representations within subspecialties were enhanced using Forest plots, displaying THA utilization rates and their 95% confidence intervals. A comprehensive gradient analysis of THA utilization rates was conducted through a multivariable regression analysis across various subspecialties and practice environments.

Regression Analyses for Geographic and Subspecialty Factors

Further regression analyses evaluated the influence of geographic factors and subspecialty on THA utilization rates. Utilizing multivariable meta-regression and linear regression techniques, these analyses quantified the impact of these factors, explicitly reporting differences in THA rates associated with country affiliation and subspecialty.

Model Significance

The overall model p-value was reported to mitigate potential Type I errors. Sub-sample representativeness was ensured through percentage meta-analysis, while geographic evaluation employed a meta-analysis approach, with subspecialties acting as subgroups.

Statistical Testing

All statistical tests were two-tailed, and significance was evaluated at 0.05.

Analysis Goals

This comprehensive statistical analysis provided a rigorous assessment of orthopedic professionals' preferences and decision-making patterns regarding the utilization of THA across various practice environments, subspecialties, and geographic regions.

Additional Results

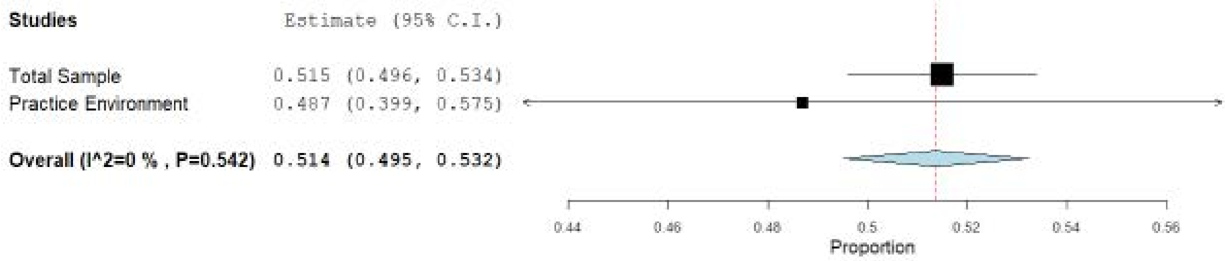

Figure 1 Appendix 2: Forest Plot

This forest plot illustrates the proportion, accompanied by 95% confidence intervals of both total respondents (n=2606) and those with a recorded practice environment (n=1056) who preferred THA. The absence of significant heterogeneity between the observed proportions (I2=0%, p=0.54) supports the representation of the practice environment cohort within the total respondent pool.

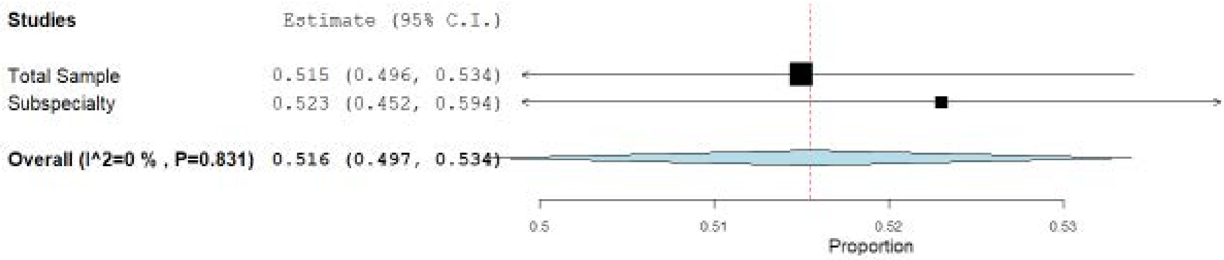

Figure 2 Appendix 2: Forest Plot

This forest plot presents the proportion and 95% confidence intervals of total respondents (n=2606) and those with a recorded practice environment (n=1752) who preferred THA. The absence of significant heterogeneity between the observed proportions (I2=0%, p=0.83) supports the representation of the "declared" subspecialized cohort within the total respondent pool.

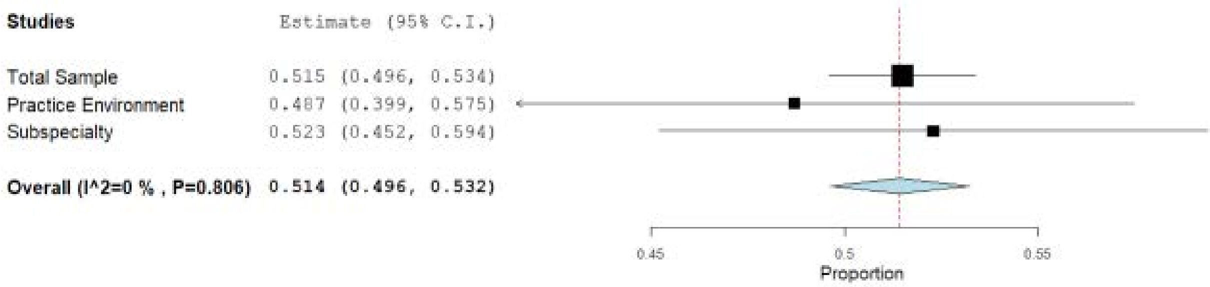

Figure 3 Appendix 2: Forest Plot Showing Internal Consistency Analysis

This forest plot illustrates the proportions and their respective 95% confidence intervals for individuals who selected THA within the entire respondent pool and within the subspecialized and practice-type cohorts. The meta-analysis indicated homogeneity of proportions (I2=0%, p=0.81), affirming the representativeness across these subgroups

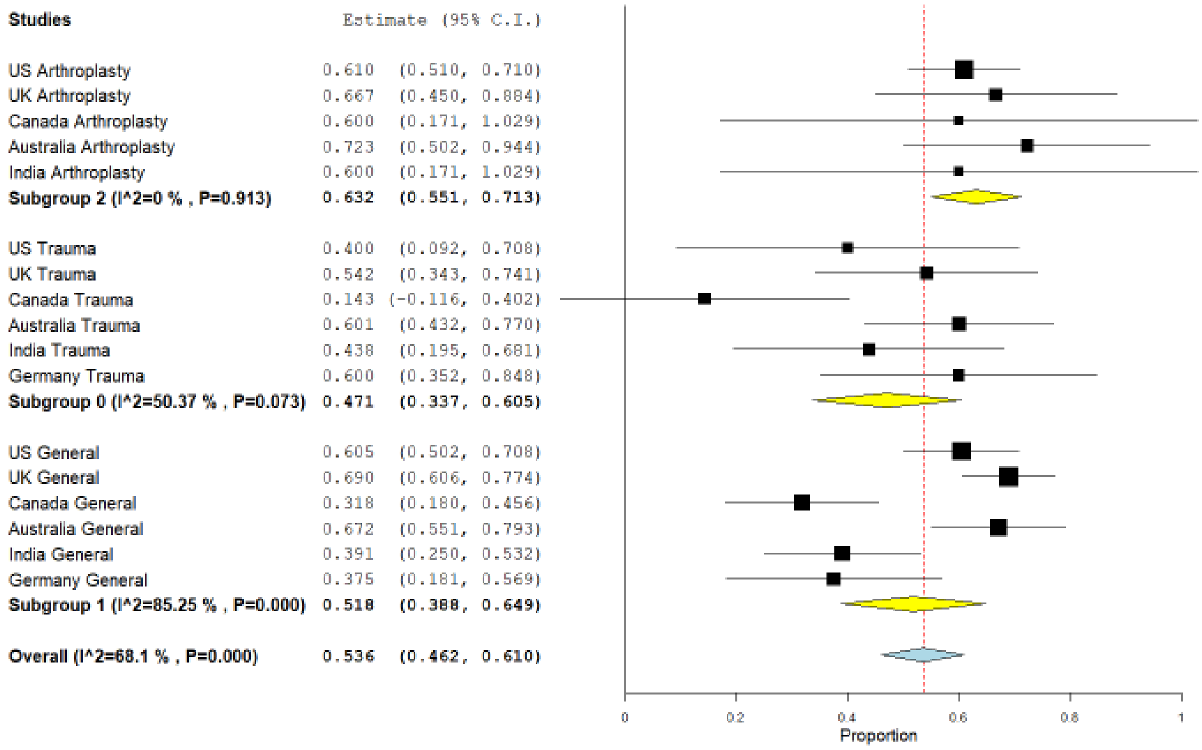

Figure 4 Appendix 2: Forest Plot of THA Rates Across Selected Countries Stratified by Subspecialty

This forest plot exhibits proportions and their respective 95% confidence intervals (CI) regarding the preference for THA across selected countries for each subspecialty. The bolded entries represent the aggregate summative proportions of THA preferences for each subspecialty across the included countries.

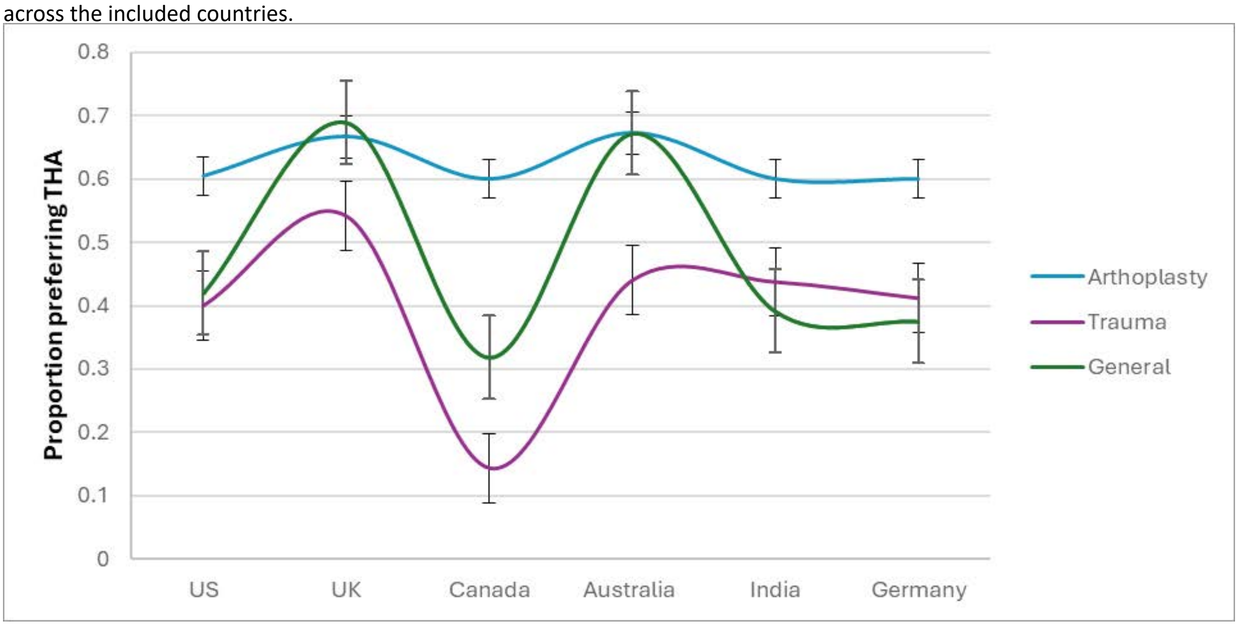

Figure 5 Appendix 2: Line Diagram of THA Rates Stratified by Subspecialty ("Pattern Displaying Line Graph": Exploring Variation and Consistency)

This line diagram depicts the proportions of respondents favouring total hip arthroplasty (THA), stratified by subspecialty and across selected countries. The visualization aims to illustrate patterns in surgical decision-making across different specialties and geographic locations.

Geographic Impact of Total Hip Arthroplasty (THA) Utilization: Insights from Extensive Survey Data

This analysis delves into the preferences for total hip arthroplasty (THA) across orthopedic subspecialties and practice environments within selected countries, providing crucial insights into the variance in surgical preferences.

Subspecialty Variances in THA Preferences

In this comprehensive assessment across selected countries, arthroplasty-trained surgeons preferred THA in approximately 63.2% of cases (95% CI 55.1 to 71.3%, I2=0%, p=0.91). Comparatively, generalists and traumatologists picked THA in 51.8% (95% CI 38.8 to 64.9%, I2=50.3%, p=0.07) and 47.1% of cases (95% CI 33.7 to 60.5%, I2=85.3%, p<0.001) respectively. These variances highlight statistically significant differences in THA preferences among subspecialties (I2=68.1%, p<0.001), indicating a substantial divergence in surgical inclinations.

While arthroplasty surgeons demonstrated minimal differences in preferences within their subgroups, notable variability emerged across selected countries for generalists (I2=50.3%) and traumatologists (I2=85.3%). The meta-analysis revealed persistent heterogeneity within countries, primarily driven by the contrast between arthroplasty and non-arthroplasty surgeons across most selected countries.

Further Analysis: Practice Environment Variation Across Subspecialties in THA Preferences

This section provides an in-depth exploration of THA preferences across orthopedic subspecialties concerning different practice environments. It examines how orthopedic surgeons' inclinations towards THA differ based on their subspecialty focus within distinct practice settings. The analysis elucidates the influence of practice environments on the preferences of surgeons specializing in various orthopedic subspecialties, shedding light on the diversity in THA utilization rates influenced by these factors.

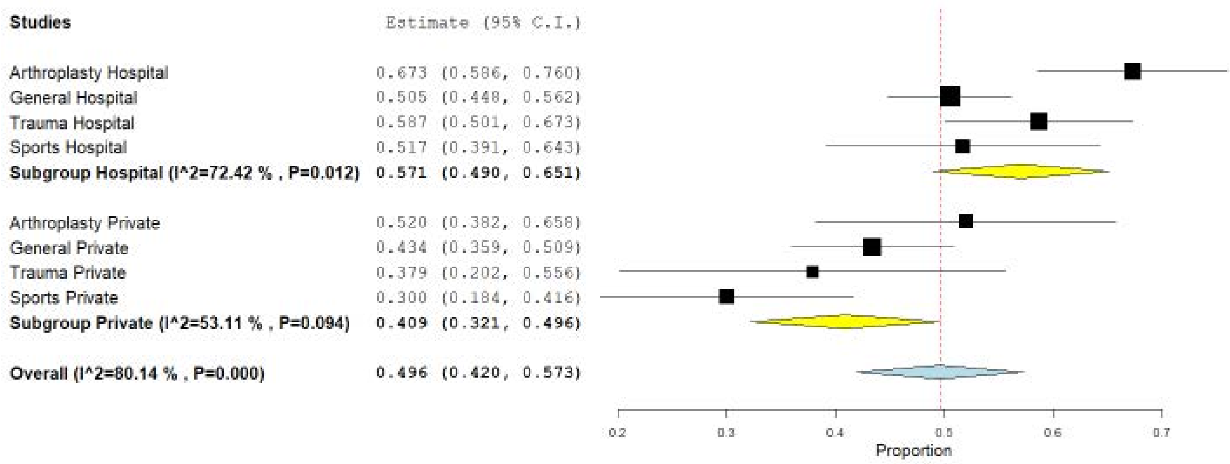

Figure 6 Appendix 2: Forest Plot of THA Rates Across Subspecialties with Subgroup Meta-analysis for Practice Environment

Forest Plot, delineating between hospital-based and private practice contexts, depicts the distribution of total hip arthroplasty (THA) utilization rates among diverse subspecialties and practice settings. The visual presentation highlights a significant 17.5% contrast in THA preference between orthopaedic surgeons working in hospital-based environments and private practice (p<0.001).

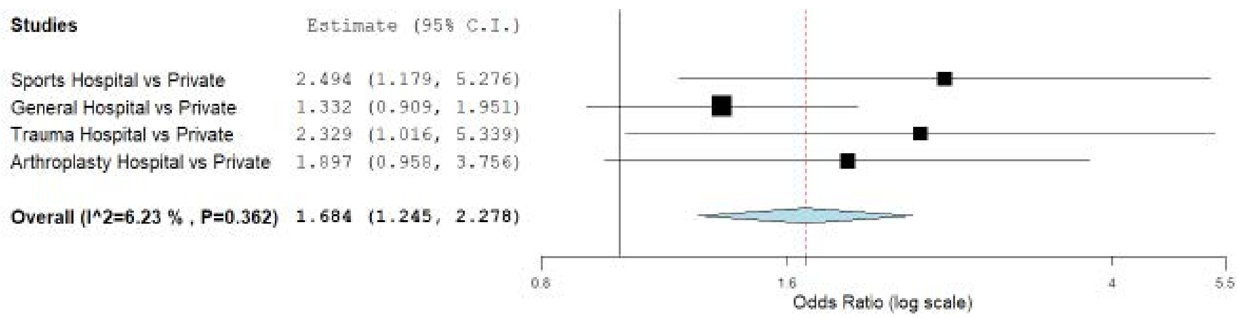

Figure 7 Appendix 2: Forest Plot Comparing Total Hip Arthroplasty (THA) Utilization between Hospital-Based and Private Practice Orthopaedic Surgeons, Stratified by Subspecialty

This visual display presents the variation in preference for total hip arthroplasty (THA) between hospital-based and private practice orthopaedic surgeons across different subspecialties. Hospital-based surgeons consistently demonstrate a higher inclination toward THA (OR 1.68, p=0.001) across various subspecialties. However, limited sample sizes restrict thorough heterogeneity testing (I2=6.2%, p=0.4). The observed discrepancies between these groups might stem from distinctive practice patterns among orthopaedic surgeons and the amplified impact of hospital settings, especially within subspecialties less associated with THA, indicating an epidemiological consideration within orthopaedics.

Discussion

1. Resource Availability and Surgical Decisions: Surveying surgical preferences is critical due to resource constraints that impact decisions and outcomes. World-class arthroplasty centers report lower complication rates, potentially driving expanded indications for total hip arthroplasty in high-risk patients in different geographical/practice contexts.
2. Interpreting Arthroplasty Outcomes: Variability in outcomes between total hip arthroplasty and hemiarthroplasty is evident, spanning mortality, adverse events, and functional effects. Timing of evaluations adds complexity to result in interpretation.
3. Survival Analysis and Outcome Focus: Insights from prior studies like Bhandari et al.'s Health Study and Griffin et al.'s trial on cemented versus uncemented fixation reveal diverse mortality rates post-surgery. The focus on rapid mortality decline post-surgery is limited within certain surgeon groups and practice environments.
4. Geographic and Educational Influences: Observations highlight varied practice trends influenced by geography and educational systems. Similar cultural backgrounds foster consistent practice patterns. Educational systems and training methods significantly shape surgical practices.
5. Consistent Familiarity with Surgical Evidence: Surgeons consistently understand surgical evidence across diverse geographical and socioeconomic backgrounds, impacting total hip arthroplasty and cemented femoral fixation rates.
6. Global Trends in Arthroplasty Utilization: Arthroplasty subgroups exhibit a substantial inclination towards higher total hip arthroplasty utilization rates, possibly stemming from a cohesive global educational approach.
7. Promotion of Practice Trends within Subspecialties: Understanding whether practice trends within subspecialties are actively promoted or adopted is essential. Bridging survey-reported changes with subspecialty societies and evidence documentation is crucial for future research directions.
8. Challenges in Orthopedics and Research Needs: Orthopedics faces challenges due to shifts in implant choices lacking robust evidence, leading to increased spending and delayed complication recognition. Robust research is imperative before expanding surgical indications.

Conclusion

The second phase of the BHA Project, part of the WORLD Collaboration, sheds light on the intricate nature of surgical decision-making for geriatric displaced femoral neck fractures. Our study highlights the pivotal roles played by practice environments, subspecialties, and geographical factors in shaping these preferences. Future research holds the key to further unravelling the complexities of orthopedic surgical decisions, ultimately improving patient care. Comprehensive international surveys, backed by increased funding, serve as a fundamental step toward understanding the nuanced factors influencing surgical choices. These surveys lay the groundwork for large-scale trials, essential in exploring patient care's intricate dynamics. Through this collective endeavour, we can optimize treatment strategies for geriatric displaced femoral neck fractures and elevate the overall quality of care for these vulnerable individuals.