


# Total Hip Arthroplasty in Nonagenarians – A National In-Patient Sample-Based Study of Perioperative Complications

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## Abstract

**Background:** Nonagenarians are a rapidly expanding population in the United States. These patients are met with increasing rates of hip arthritis, necessitating the need for total hip arthroplasty (THA). However, there is currently limited information on hospitalization information and perioperative complications in this population. **Methods:** In this retrospective study, we used the Nationwide Inpatient Sample (NIS) database from 2016-2019 to analyze the incidence of perioperative complications, length of stay (LOS), and the cost of care (COC) among patients undergoing THAs who were categorized as nonagenarians, and those who were not. **Results:** The NIS database identified 309 100 patients who underwent THAs from 2016-2019. Of those, 1864 patients (.6%) were nonagenarian, while the remaining 307 236 patients were included under the non-nonagenarian category (control). The mean age in the nonagenarian group was 90 years compared to the control group which had a mean age of 65.8 years. There was an increased incidence of mortality rate (nonagenarian group .2%, control group .03%,  $P < .001$ ), myocardial infarction (MI) (nonagenarian group .1%, control group .02%,  $P = .01$ ), acute renal failure (ARF) (nonagenarian group 5.4%, control group 1.6%,  $P < .001$ ), blood anemia post-operatively (nonagenarian group 28.9%, control group 17.2%,  $P < .001$ ), and deep vein thrombosis (DVT) (nonagenarian group .48%, control group .07%,  $P < .001$ ) in the nonagenarian group. The COC for the nonagenarian group was higher than that in the control group ( $P < .001$ ). The mean LOS was longer in the nonagenarian group (3.1 days) in comparison to the control group (1.96 days) ( $P < .001$ ). **Conclusions:** Nonagenarians had significantly higher rates of both orthopedics and medical complications than the younger patients undergoing THAs. In addition, the nonagenarian group incurred higher COC. This information is useful for the providers to make informed decisions regarding patient care and resource utilization for nonagenarian patients undergoing THAs.

## Keywords

nonagenarians, total hip arthroplasty, postoperative complications, cost of care, length of stay

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## Introduction

There are limited health statistics available for the rapidly expanding population aged 90 years or more (nonagenarians) in the United States (U.S.). It is estimated that by 2050, nonagenarians will account for approximately 71 million of the world's population.<sup>1</sup> It is anticipated that the prevalence of hip arthritis and the need for total hip arthroplasty (THA) will continue to increase in this age group.<sup>2</sup> Total hip arthroplasty is a proven successful procedure to improve the quality of life and functional capacity in patients with hip arthritis. Globally, there are more than 1 million THAs performed each year.<sup>3,4</sup>

While THA is beneficial for many nonagenarian patients, associated medical comorbidities potentially can lead to higher rates of perioperative complications.<sup>5,6</sup> A previous study reported on the outcomes of primary THAs from 2010-2014 found that the nonagenarians had higher rates of transfusions, urinary tract infection, acute kidney injury, longer hospital stays, and higher hospital charges compared to the octogenarians.<sup>7</sup> The authors did not report data on surgical complications such as surgical site infection, periprosthetic fracture, or dislocation. Additionally, there is a higher in-hospital mortality rate in nonagenarian patients due to medical co-morbidities and complications.<sup>6</sup> Moreover, after non-cardiac and non-trauma-related surgeries, nonagenarians have an increase in postoperative mortality rates.<sup>8</sup>

Other studies have reported THA and total knee arthroplasty (TKA) in this population are associated with increased hospital costs, increased length of stay (LOS), and higher complication rates.<sup>9,10</sup> The purpose of this study was to query a large patient database (the Nationwide Inpatient Sample (NIS) Database) to evaluate the patient characteristics, demographics, and incidence of postoperative complications among nonagenarian patients who underwent primary THAs. We hypothesize that the nonagenarians will have higher rates of perioperative complications, longer hospitalization, and higher costs associated with their care. To our knowledge, this is the first study that has studied perioperative complications, charges associated with healthcare costs, demographic variables, and patient admission characteristics using a large database such as the NIS.

## Methods

### Database Description

The NIS is the largest publicly available all-payer inpatient care database in the U.S. The NIS contains data on more than 7 million hospital stays. This database is one of a group of databases and software tools

developed for the Healthcare Cost and Utilization Project (HCUP). It was developed through a Federal-State-Industry partnership sponsored by the Agency for Healthcare Research and Quality (AHRQ). Its large sample size is ideal for developing national and regional estimates and enables analyses of rare conditions, uncommon treatments, and special populations such as the nonagenarians undergoing THAs. The data are based on an independent contractor's quality assessment review that compares data points with established normative values. The NIS data are obtained from 20% of the hospitals in the U.S. Demographic information, LOS, payment source, hospital charges, discharge status, comorbidities, and other data variables are all included in the NIS database. The International Classification of Diseases (ICDs), 10th Revision, Clinical Modification/Procedure Coding System in the 2016-2019 version is used in the NIS to identify the disease states and the procedures.

### Data Acquisition

This study was exempted from approval by our Institutional Review Board (IRB) since the data are de-identified and publicly available. All patients with the ICD-10, and the Clinical Modification/Procedure Coding System (CMP) codes for THA were included in this study. Patients were then classified into 2 groups: the nonagenarians and the non-nonagenarians (control). Data was extracted from the period 2016-2019. The ICD-10 codes used for this study are described in [Appendix A](#).

The demographic data extracted included age, sex, ethnicity, and the presence of obesity. The medical comorbidities and the postoperative medical complications [postoperative anemia, acute renal failure (ARF), deep vein thrombosis (DVT), pulmonary embolism (PE), myocardial infarction (MI), and pneumonia] were also extracted. We also extracted data on surgical complications including periprosthetic infections (PPIs), prosthetic dislocations, and periprosthetic fractures. Moreover, data related to the patients' dispositions after the acute hospital care were extracted [short-term hospital, home/routine, another type of facility, home healthcare (HHC), left against medical device (LAMA)]. Lastly, we extracted and analyzed the financial data on the total charges of care for the patients.

### Statistical Analysis

SPSS version 27.0 was used for all statistical analyses (IBM; Armonk, NY, USA). Demographic information about patients was initially compiled using descriptive statistics. When examining numerical variables, T-tests were employed. Binomial variables were examined

**Table 1.** Patient Demographic Characteristics of Nonagenarians and the Control Group.

|                             | Nonagenarian (1864) | Control Group (307 236) | Significance    |
|-----------------------------|---------------------|-------------------------|-----------------|
| Age in years at admission   | 90                  | 65.79                   | N/A             |
| Sex (proportion of females) | 171 179 (55.7%)     | 1295 (69.5%)            | <b>&lt;.001</b> |
| Obesity                     | 87 (4.8%)           | 70 576 (22.9%)          | <b>&lt;.001</b> |
| Race                        |                     |                         |                 |
| Caucasian                   | 1669 (93.8%)        | 254 542 (86%)           | <b>&lt;.001</b> |
| African American            | 28 (1.6%)           | 22 789 (7.7%)           |                 |
| Hispanic                    | 36 (2.0%)           | 10 352 (3.5%)           |                 |
| Asian or Pacific islander   | (.8%)               | 2550 (.9%)              |                 |
| Native American             | (.3%)               | 881 (.3%)               |                 |
| Other                       | 28 (1.6%)           | 4835 (1.6%)             |                 |

Note. Bolded values indicate statistical significance.

Numbers between 1 and 10 were not reported as per healthcare cost and utilization project (HCUP) data use agreement.

using chi-squared analysis. When the incidence values were less than 5, Fisher Exact tests were applied. For all tests, a *P*-value of .05 or lower was regarded as statistically significant. As a ratio of the incidence in the nonagenarian group to the incidence in the control group, odds ratios and their accompanying 95% confidence intervals for surgical outcomes and complications were calculated.

## Results

### Patient Demographic Data Analysis

A total of 309 100 patients were identified in the NIS database who underwent THAs during the study period. Of this cohort, 1864 patients (.6%) were nonagenarian, while the remaining 307 236 patients were in the non-nonagenarian group (control). The demographic data for the groups are included in Table 1. While the mean age of the nonagenarian patients was 90 years, the mean age in the control group was 65.9 ± 10.5 years. There was a significantly greater proportion of females in comparison to males in both the nonagenarian and the control groups. The control group had a higher proportion of patients with obesity. Patients' ethnicity revealed that there is a significantly greater proportion of Caucasians in comparison to other races such as African American, Asian or Pacific Islander, and Native American, which was demonstrated in both nonagenarians and the control group (Table 1).

### In-patient Data Analysis

Compared to the control group, nonagenarians had a significantly less proportion of patients who were admitted electively vs non-electively (95.9% in Nonagenarians vs 97.2% in controls, *P* = .001). The LOS in the hospital was significantly different between the groups (3.1 ± 2 days in nonagenarians vs 1.96 ± 1.6 in controls, *P* < .001) The total charges for the care (\$65,429.2 ± \$41,325.4 vs \$62,050.9 ± \$37,951.2) were

significantly greater in the nonagenarians compared to in the controls (*P* < .001). Nonagenarians were significantly less likely to identify with tobacco-related disorders compared to the control group patients (12.8% vs 18.2%, respectively, *P* < .001). Lastly, nonagenarians had a significantly lower rate of diabetes without complications (6%) than patients in the control group (10.3%, *P* < .001). There was no significant difference between the groups about the prevalence of Parkinson's disease and rheumatoid arthritis (Table 2).

Regarding the patient discharge information, fewer nonagenarians were discharged to home care compared to the control group (12.2% in nonagenarians vs 41.3% in controls, *P* < .001). Additionally, fewer nonagenarian patients used HHC compared to the control group (24.2% in control vs 44.3%, *P* < .001). A much higher proportion of the nonagenarian patients were discharged to an in-patient subacute care facility than in the control patients (62.9% in nonagenarians vs 14% in controls, *P* < .001) Interestingly, a greater proportion of the nonagenarian patients were identified as "Left Against Medical Advice" (LAMA) vs the control patients (.43% in nonagenarians vs .18% in controls, *P* < .001). (Table 3).

### Complications and Adverse Events During the Hospital Admission

The nonagenarian patients had a 7.6 times higher in-hospital mortality than the control patients (.21% in nonagenarians vs .03% in controls, *P* < .001). The nonagenarian patients were found to have a significantly greater incidence of postoperative anemia, greater blood transfusions, postoperative renal failure, MI, pneumonia, PPIs, periprosthetic dislocations, and DVT. There was no statistically significant difference between the nonagenarians and the controls about the incidence of PE (Table 3).

**Table 2.** Admission Characteristics of Nonagenarians and Controls.

|  | Nonagenarian (1864)      | Control Group (307 236)  | Significance    |
|--|--------------------------|--------------------------|-----------------|
| Length of stay (cleaned)               | 3.1 (SD = 2)             | 1.96 (SD = 1.6)          | <b>&lt;.001</b> |
| Total charges (cleaned)                | 65 429.2 (SD = 41 325.4) | 62 050.9 (SD = 37 951.2) | <b>&lt;.001</b> |
| Elective versus non-elective admission | 1783 (95.9%)             | 298 122 (97.2%)          | <b>.001</b>     |
| Tobacco related disorder               | 238 (12.8%)              | 55 913 (18.20%)          | <b>&lt;.001</b> |
| Dialysis                               | 0                        | 187 (.1%)                | .29             |
| Parkinson's disease                    | 11 (.6%)                 | 1 169 (.4%)              | .14             |
| Rheumatoid arthritis                   | (.2%)                    | 588 (.20%)               | .76             |
| Diabetes without complications         | 112 (6%)                 | 31 675 (10.3%)           | <b>&lt;.001</b> |
| Patient disposition                    |                          |                          |                 |
| Home/Routine                           | 227 (12.2%)              | 126 955 (41.3%)          | <b>&lt;.001</b> |
| Short-term hospital                    | .4%                      | 555 (.20%)               |                 |
| Another type of facility               | 1 172 (62.9%)            | 43 328 (14%)             |                 |
| Home healthcare (HHC)                  | 451 (24.2%)              | 136 027 (44.3%)          |                 |
| Left against medical device (LAMA)     | (.1%)                    | 166 (.1%)                |                 |
| Died                                   | (.2%)                    | 87 (.03%)                |                 |

Note. Bolded values indicate statistical significance.

Numbers between 1 and 10 were not reported as per healthcare cost and utilization project (HCUP) data use agreement.

**Table 3.** In-Hospital Complications of Nonagenarians and the Control Group.

| Post-Operative Variables    | Nonagenarian Group (1864) | Control Group (307 236) | Odds Ratio (Nonagenarian/Control Group) | 95% Confidence Interval | Significance    |
|-----------------------------|---------------------------|-------------------------|---|-------------------------|-----------------|
| Died during hospitalization | (.2%)                     | 87 (.03%)               | 7.6                                     | (2.8, 20.7)             | <b>&lt;.001</b> |
| Acute renal failure         | 100 (5.4%)                | 4925 (1.6%)             | 3.5                                     | (2.8, 4.3)              | <b>&lt;.001</b> |
| Myocardial infarction       | (.1%)                     | 55 (.02%)               | 5.9                                     | (1.5, 24.6)             | <b>.01</b>      |
| Blood loss anemia           | 539 (28.9%)               | 52 704 (17.2%)          | 1.9                                     | (1.8, 2.2)              | <b>&lt;.001</b> |
| Pneumonia                   | 18 (.97%)                 | 359 (.1%)               | 8.4                                     | (5.2, 13.4)             | <b>&lt;.001</b> |
| Blood transfusion           | 162 (8.7%)                | 6567 (2.1%)             | 4.4                                     | (3.7, 5.1)              | <b>&lt;.001</b> |
| Pulmonary embolism          | (.05%)                    | 229 (.07%)              | 0.7                                     | (.1, 5.1)               | 0.7             |
| Deep vein thrombosis        | (.48%)                    | 228 (.07%)              | 6.5                                     | (3.4, 12.7)             | <b>&lt;.001</b> |
| Periprosthetic fracture     | 18 (.97%)                 | 1642 (.5%)              | 1.8                                     | (1.1, 2.9)              | <b>.01</b>      |
| Periprosthetic dislocation  | (.38%)                    | 531 (.2%)               | 2.2                                     | (1, 4.6)                | <b>.04</b>      |
| Periprosthetic infection    | (.05%)                    | 21 (.006%)              | 7.86                                    | (1.1, 58.4)             | <b>.02</b>      |

Note. Bolded values indicate statistical significance.

Numbers between 1 and 10 were not reported as per healthcare cost and utilization project (HCUP) data use agreement.

## Discussion

Over the past 10 years, there has been a consistent increase in the utilization of THAs worldwide.<sup>11</sup> More nonagenarians are candidates for THAs.<sup>2</sup> Nonagenarians are at a greater risk of perioperative complications.<sup>9</sup> Previous studies have demonstrated a higher risk of complications following THAs.<sup>2,5,12,13</sup> The nonagenarians are often with

medical co-morbidities, some of which may not be modifiable before or after THAs.<sup>6</sup>

The purpose of the present study was to analyze the outcomes and the complications in nonagenarians undergoing primary THAs in a contemporary large database in the U.S. The current analysis confirmed previously reported findings by Miric et al.<sup>2</sup> The demographics favored females, Caucasians, and being thinner than the

younger patient group. Nonagenarians have higher incidences of frailty, as measured using validated assessment instruments. Higher frailty severity has been associated with higher mortality, higher medical complications, and longer hospital stay in patients undergoing a variety of surgical procedures.<sup>14-17</sup>

There have been many advances in the multi-disciplinary approach to managing the geriatric patient population over the past several decades. Despite these advances, nonagenarian patients require longer acute in-patient care stays. There has been little improvement in shortening the LOS when compared to the previous data.<sup>2,10</sup> The longer hospital stay is attributed to many factors, not just the higher perioperative complications.<sup>5,9,12</sup> Our data confirmed previously reported data on the higher cost of care (COC) in this patient population. Fang et al, reported that nonagenarians had significantly higher implant and total-in-hospital costs for total joint arthroplasty in comparison to octogenarians.<sup>18</sup> We observed that the nonagenarians had significantly higher average total costs associated with their care (USD 65,429.2) than the controls (USD 62,050.9).

Our data demonstrated that the nonagenarians were more likely to develop DVTs following THA. There were no significant differences in the PE rates between the groups. Similar findings were previously reported in other studies.<sup>2</sup> In addition, the need for blood transfusion was greater in the nonagenarians. This is likely correlated to the higher incidence of blood loss anemias. Additionally, the nonagenarians had greater perioperative urinary tract infections and perioperative infections.<sup>5,16,17</sup>

The discharge planning differed between the 2 groups. Most nonagenarian patients were discharged to other in-patient facilities such as skilled nursing units and rehabilitation facilities. In contrast, the control group patients were more likely to be discharged to home, with or without home care services. Additionally, more nonagenarian patients died after discharge in comparison to the control patients. This underscores the need for careful disposition and longitudinal care planning before the surgery. This will reduce the potential delays in transitional care, hopefully reducing healthcare costs with shorter lengths of stay in acute inpatient care.

The data from this study demonstrated several important findings. (1) The in-hospital mortality was .21% for the nonagenarians with 99.8% of the patients surviving the index acute care episode. (2) Acute blood loss anemia was documented in 28.9% of the patient, however only 8.69% of the patients required blood transfusion. This is different from reports, as previous studies have reported a 35-35.5% rate of transfusion in this elder population.<sup>12,19</sup> We speculate that this could be due to the differences in the definition of acute loss anemia, and the changes in the transfusion trigger in the clinical practice. (3) Overall, the surgical complications were low:

periprosthetic fractures (.97%), dislocations (.38%), and surgical site infections (.05%).

## Limitations

The NIS is the largest available database involving all payers, providing us with an excellent sample size to study THA complications in nonagenarians. Nevertheless, this database only records administrative data for the initial hospitalization, resulting in variable levels of reliability. Our study, therefore, lacks long-term outcome data following patient disposition, an important metric for arthroplasty. Despite the reasonable accuracy of the information coded in NIS (specificity >92%), this information may be incomplete. In addition, nonagenarians with hip fractures were included in the study, which may introduce a potential bias since this population is met with higher rates of perioperative complications and morbidity.<sup>20</sup> However, over 95% of nonagenarian patients elected to undergo THA, which may lessen the impact of hip fractures on perioperative complications and hospital characteristics.

## Conclusions

This large database study found that nonagenarians have higher rates of perioperative complications following primary THA than patients less than 90 years of age. Despite the higher complication rate, more than 99% of patients survived the hospitalization, and the periprosthetic complication rate of fracture, dislocation, and infection was individually less than 1%. This study provides data to patients, providers, and healthcare organizations regarding the perioperative outcomes of primary THA in nonagenarians. Preoperative optimization and perioperative multidisciplinary management of these patients potentially can allow nonagenarians to safely undergo primary THA, albeit with higher complication rates compared to younger patients. In this age group, the increased rate of perioperative complications should be considered when estimating hospital costs.

## Author Contributions

Nikit Venishetty had full access to all study data and takes complete responsibility for data integrity and statistical analysis accuracy. Study concept and design: Mr. Venishetty and Dr Sambandam. Statistical Analysis: Mr. Venishetty and Dr Sambandam. Interpretation of the data: Mr. Venishetty, Mr. Toutoungy, Dr Beale, Dr Martinez, Dr Wukich, Dr Mounasamy, Dr Huo and Dr Sambandam. Initial Draft of the manuscript: Mr. Venishetty, Mr. Toutoungy, and Dr Sambandam. Final approval of the manuscript: All authors Study Supervision: Dr Wukich and Dr Sambandam.



## Declaration of conflicting interests

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## Ethical Statement

This study was exempted from approval by our Institutional Review Board (IRB) since the data are de-identified and publicly available.

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## Supplemental Material

Supplemental material for this article is available online.

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