BMC Musculoskeletal Disorders

RESEARCH

Open Access

# Characteristics of clinical trials related to hip fractures and factors associated with completion

Shengjie Wang[1†], Fan Xiong[2†], Yanzheng Gao[3], Mingxing Lei[4,5,6*] and Xianlong Zhang[1*]

## Abstract

**Background:** This study aimed at investigating the characteristics of clinical trials related to hip fractures that were registered at ClinicalTrials.gov. It also aimed to identify potential risk factors associated with completion.

**Main body:** We obtained 733 clinical studies related to hip fractures from the ClinicalTrials.gov database and included 470 studies in the analysis. These clinical trials were divided into behavioral, drug/biological, device, procedure, and other categories based on intervention types. Clinical trials investigating drugs or biologics were categorized based on the specific agents administered in each trial. Multiple logistic and Cox regression models were used to test the ability of 24 potential risk factors in predicting recruitment status and completion time, respectively. Among the included clinical trials, 44.89% (211/470) had complete recruitment status. The overall median completion time was 931.00 days (95% confidence interval [CI]: 822.56–1039.44 days). The results of only 8.94% (42/470) of clinical trials were presented on the ClinicalTrials.gov website. Bupivacaine (a local anesthetic) was most commonly investigated (in 25 clinical trials); this was followed by ropivacaine (another local anesthetic, 23 clinical trials) and tranexamic acid (a hemostatic, 21 clinical trials). Multivariate analysis showed that trials including children ($P=0.03$) and having National Institutes of Health funds ($P<0.01$) had significantly higher rates of complete recruitment. Higher enrollment ($P<0.01$), National Institutes of Health funding ($P<0.01$), location in the United States ($P=0.04$), and location in Europe ($P=0.03$) predisposed to longer completion time, while studies involving drugs/biologics ($P<0.01$) had shorter completion times.

**Conclusions:** A considerable proportion of clinical trials related to hip fractures were completed, but the results of only a small fraction were presented on the ClinicalTrials.gov website. The commonly investigated drugs focused on anesthesia, pain relief, and hemostasis. Several independent risk factors that affect recruitment status and completion time were identified. These factors may guide the design of clinical trials relating to hip fractures.

**Keywords:** Clinical trials, Hip fractures, ClinicalTrials.gov, Completeness, Drugs/biologics

## Background

Hip fractures have become a significant global public health problem due to the gradual ageing of the population. Elderly patients, especially women, usually suffer from a reduction of bone mineral density and an increasing risk of falls, both of which are responsible for the pathogenesis of hip fractures. According to the literature, this disease approximately affects 18% females and 6% males globally. It has been estimated that the number

†Shengjie Wang and Fan Xiong contributed equally to the paper.

*Correspondence: 825979020@qq.com; dr_zhangxianlong@163.com

[1] Department of Orthopaedic Surgery, Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University, Yishan Road 600#, Shanghai 200233, China
[4] Chinese PLA Medical School, 28 Fuxing Road, Beijing 100853, China
Full list of author information is available at the end of the article

© The Author(s) 2022. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

of hip fractures worldwide will rise from 1.26 million (30 years previously) to approximately 4.5 million in 2050 [1]. Owing to long-term hospitalization and rehabilitation, the corresponding economic impact on healthcare is expected to be enormous. In addition, hip fractures may subsequently lead to disabilities, mortality, secondary fractures, and cardiovascular diseases [2], among other conditions.

A series of clinical trials have been conducted with the aim of preventing or treating hip fractures. These clinical trials are mostly registered on the ClinicalTrial.gov database, which was launched in 2000; it is the largest global trial repository that allows patients, medical workers, and the public to easily access basic information about publicly and privately supported clinical research on a variety of diseases or conditions. The International Committee of Medical Journal Editors has declared that only clinical studies registered at ClinicalTrials.gov before patient recruitment may be considered for publication. The registration of clinical trials became a prerequisite for publication after the issue of the Food and Drug Administration Modernization Act of 1997 [3]; in this context, there are legal repercussions if the new registrations are not accurate [4].

Studies pertaining to orthopedic trauma trials published ten years previously [3], prospective spine studies [5], spinal cord injury trials [6], rheumatoid arthritis trials [7], and sports medicine-related randomized controlled trials [8] have been published following registration in Clinicaltrials.gov. However, these studies aimed at investigating the relationship between clinical trials and corresponding publications. Articles summarizing the characteristics of clinical trials relating to orthopedics, and particularly hip fractures, are scarce. A good understanding of the characteristics may be able to guide future research on hip fractures. In addition, the identification of potential risk factors associated with completion may help to reduce wastage of resources and improve efficiency of clinical trials specifically related to hip fractures.

Therefore, this study aimed to investigate the characteristics of clinical trials related to hip fractures and identify potential risk factors associated with completion, as this could reduce wastage of resources and improve efficiency. We hypothesized that this study could provide valuable insights into the characteristics associated with recruitment status and completion time in clinical trials related to hip fractures.

## Methods

### Registry search

We searched the ClinicalTrials.gov web site for clinical studies related to hip fractures (https://clinicaltrials.gov/, accessed on 10 July 2021). The search was conducted using the following keywords in the "condition or disease" field in ClinicalTrials.gov: "hip fractures" OR "trochanteric fractures" OR "intertrochanteric fractures" OR "subtrochanteric fractures" OR "femoral neck fractures" OR "femur neck fractures" OR "femoral head fractures" OR "femur head fractures." We then downloaded all results and reviewed each trial identified by the search. Studies were excluded if they did not meet the requirement of clinical trials adopted by the World Health Organization. As per the requirements, a clinical trial involves prospective assignment of human participants to one or more groups and treatment with medical interventions for evaluating the effects on health-related outcomes. According to the definition, observational studies were excluded. Studies that were withdrawn, not related to hip fractures, and having missing data were also excluded.

Patients were not involved in any aspect of the study design or conduct, or in the development of the research question. The present study analyzed existing publicly available data; active patient recruitment was therefore not performed for data collection. The Ethics Committee Board of the Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University waived the need for informed consent, as all data were publicly available at https://clinicaltrials.gov/. This study adhered to the principles of the Declaration of Helsinki.

### Classification of clinical trials

After exclusion, we divided the remaining clinical trials into behavioral, drug/biological, device, procedure, and other intervention categories based on intervention type. Clinical trials investigating drugs or biologics were categorized based on the agents administered in each trial. We have discussed the agents tested in three or more clinical trials and the function of these agents. If a particular drug or biologic was administered to participants in any of the therapeutic arms of the trial, this drug or biologic was regarded as being involved in the clinical trial.

A bar chart was drawn to identify the trends of newly registered clinical trial numbers with time; the trial location categories were as follows: China, the United States, Europe, Canada, and others. A bar chart was also constructed on the relative proportion of newly registered clinical trials on ClinicalTrials.gov, based on the five different locations.

### Characteristics of clinical trials

We have presented data pertaining to the recruitment status, whether study results were shown on the ClinicalTrials.gov website, start date (years), outcome measures

including mortality, participant's gender and age, phases, number of enrollments, funders, study design, primary purpose, interventions, trial locations, and completion time.

Recruitment status included the following categories: not yet recruiting, recruiting, enrolling by invitation, active, not recruiting, suspended, completed, and unknown. If the outcome measures of a trial involved mortality, the trial was considered in the "outcome measures including mortality" category. During analysis of the data, clinical trials involving phases 1 and 2 were regarded as phase 2 trials, while those marked as phase 2 and 3 were considered as phase 3. Funders included the National Institutes of Health (NIH), industry, and others. Study designs included the following factors: allocation, intervention model, and masking. The primary purpose included the following categories: diagnostic, health service research, prevention, supportive care, treatment, and others. Interventions included behavioral, drug/biological, device, procedure, and others. Trial locations were categorized as follows: China, the United States, Europe, Canada, and others. Completion time was defined as the time interval between the start and completion dates. The completion date was divided into actual and estimated dates. The actual completion date of a clinical study was defined as that on which the last participant was examined or received an intervention for collection of final data for the primary outcome measure; the estimated completion date was the expected primary completion date for the study.

### Potential risk factors associated with recruitment status, completion time, and successful trial completion on ClinicalTrials.gov

We identified 24 potential risk factors for predicting recruitment status, completion time, and successful trial completion; these included outcome measures including mortality (yes vs. no), gender (male vs. female vs. both), participants including children (yes vs. no), age including older adults (yes vs. no), phases (not applicable, phase 1, phase 2, phase 3, or phase 4), enrollment ($\leq 50$ vs. $> 50$, $\leq 100$ vs. $> 100$, $\leq 200$ vs. $> 200$, and $\leq 400$ vs. $> 400$), being funded by the NIH (yes vs. no), being funded by industry (yes vs. no), allocation (not applicable, non-randomized, or randomized), intervention model (single, sequential, parallel, factorial, or crossover), masking (none, single, double, triple, or quadruple), primary purpose (diagnostic [yes vs. no], health service research [yes vs. no], prevention [yes vs. no], supportive care [yes vs. no], and treatment [yes vs. no]), interventions (behavioral [yes vs. no], drug/biological [yes vs. no], device [yes vs. no], and procedure [yes vs. no]), and locations (in China [yes vs. no], the United States [yes vs. no], Europe [yes vs. no], and Canada [yes vs. no]).

Participants aged 17 years or less were defined as children; those older than 65 years were defined as older adults. The industry funders included pharmaceutical and device companies. Allocation referred to the method used to assign participants to a therapeutic arm; this included the following categories: not applicable, non-randomized, and randomized. The intervention model referred to the general design of the strategy for assigning interventions to participants. Masking indicated the clinical trial design strategy; it included open label, single blind masking, and double-blind masking approaches, where one or more parties were unaware of the specific participants who were assigned to a particular intervention. Successful trial completion was defined as the availability of results on the ClinicalTrials.gov website.

### Statistical analysis

We have presented descriptive data for each category, including proportions for categorical data and medians with 95% confidence intervals (CIs) for completion time. Univariate and multivariate analyses of characteristics for recruitment status and final successful trial completion (having results on the ClinicalTrials.gov website) were both performed using simple and multiple logistic regression models. In the models, recruitment status was classified into two or seven categories. Among the significant variables identified on multivariate analysis, the distribution of recruitment status was further investigated using the Chi-square or Mantel–Haenszel Chi-square tests. Availability of results on the ClinicalTrials.gov website was classified into two categories (yes vs. no). The predictive performance of significant variables for successful trial completion was measured by area under the receiver operating characteristic (AUROC) curves. Simple and multiple Cox regression models were used to test the ability of potential risk factors in predicting completion time. Cumulative completion curves obtained using the log-rank test have been presented. Subgroup analysis was performed to test the ability of potential risk factors in predicting actual completion time; a $P$ value of 0.05 or less (two-sided tests) was considered as statistically significant. All data processing, statistical analysis, and plotting were performed using SAS 9.4, IBM SPSS Statistics 21.0, and R 4.0.5 (https://www.r-project.org/) software.

## Results

### Characteristics of clinical trials related to hip fractures

A total of 733 clinical studies related to hip fractures were obtained from the ClinicalTrials.gov database.

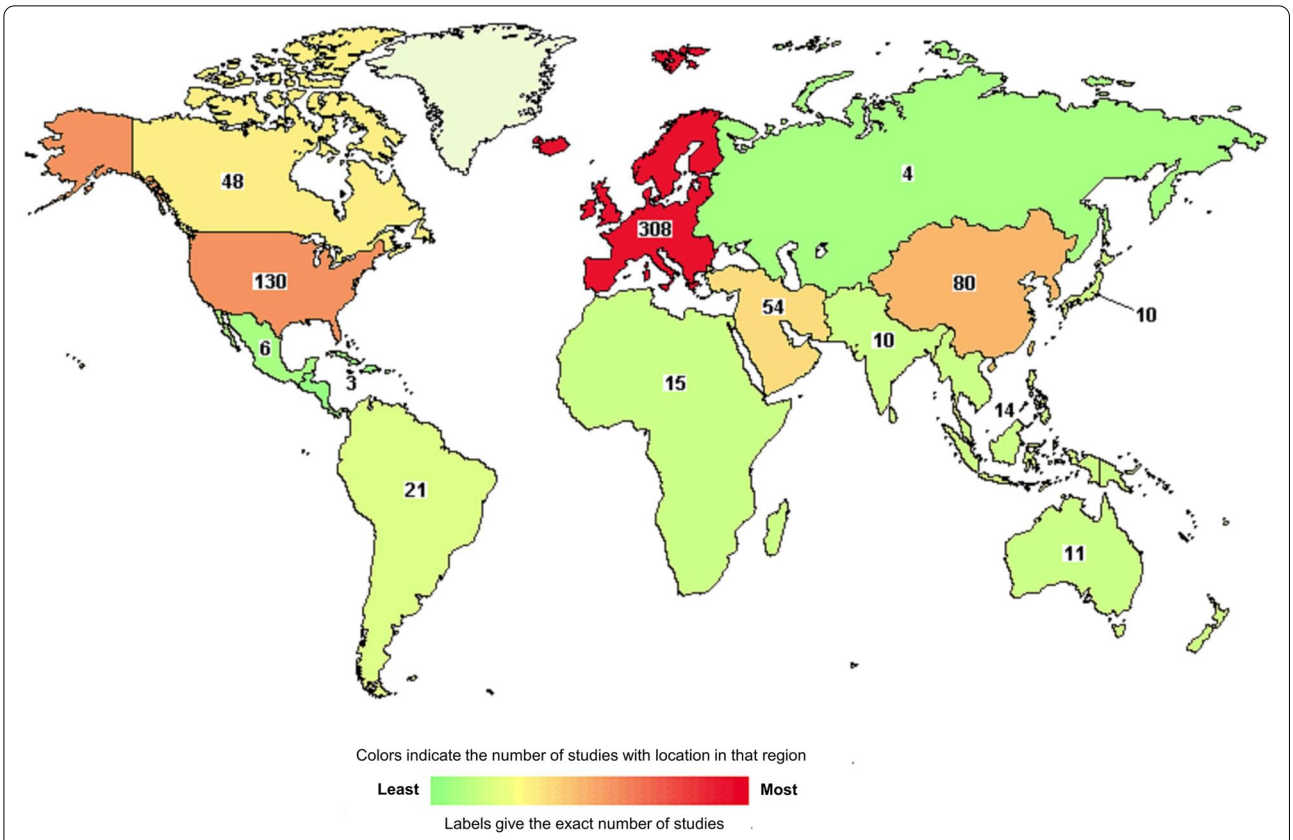


**Fig. 1** Heat map of the number of clinical studies related to hip fracture worldwide (Green indicates the least; Red indicates the most)

A map of the worldwide distribution and number of clinical studies is shown in Fig. 1. It indicates that a multitude of clinical studies related to hip fractures were performed at Europe, followed by the United States. Based on the exclusion and inclusion criteria, 470 clinical trials were finally included in the analysis. Figure 2 shows the flow chart of the included clinical trials.

Clinical trials that had complete recruitment status accounted for 44.89% (211/470) of all included studies

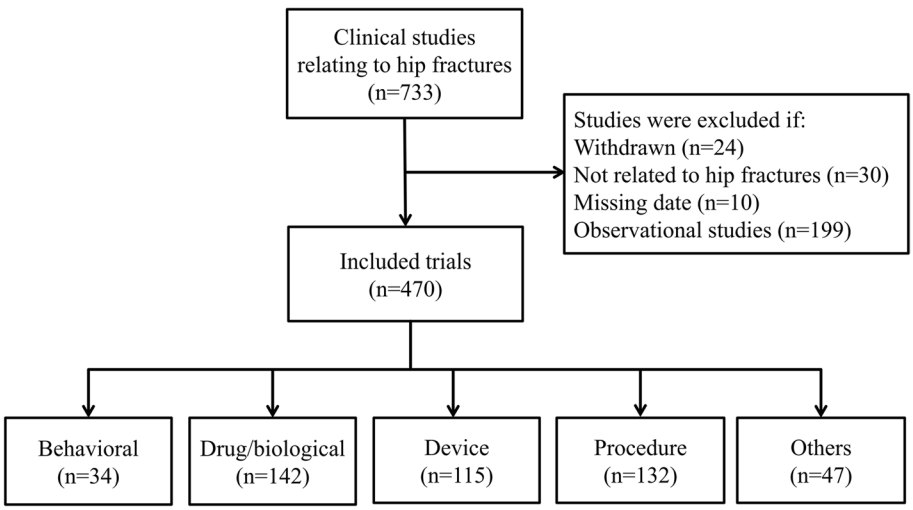


**Fig. 2** Flow chart of included clinical trials related to hip fracture registered at ClinicalTrials.gov

(Table 1). The overall median completion time was 931.00 (95% CI: 822.56–1039.44) days. Only the results of 8.94% (42/470) of clinical trials were presented on the ClinicalTrials.gov website. Almost 98.09% (461/470) of the trials included older adults, as hip fractures usually tend to occur in the geriatric population due to osteoporosis. Regarding the phases, 67.02% (315/470) clinical trials were of the not applicable category, followed by phase 4 (15.96%, 75/470) and phase 3 (10.43%, 49/470) trials. Among the included clinical trials, 75.74% (356/470) had 200 or fewer participants, only 3.83% (18/470) were funded by the NIH, and 39.57% (186/470) did not employ masking; all these may indicate that the majority of clinical trials were relatively small. The most common primary purpose was treatment (68.09%, 320/470) and the most common intervention was drug/biological therapy (30.21%, 142/470).

After exclusion of irrelevant clinical studies, Europe continued to have the largest number of trials with a proportion of 41.70% (196/470); this was followed by the United States (21.28%, 100/470) and China (9.36%, 44/470). In general, based on the findings on the density curve (Fig. 3A), clinical trials on hip fractures were developed early in the United States since its curve began to steadily increase at the beginning of 1990, and the time was earlier than that of any other countries; in China, the number of clinical trials related to hip fractures mostly increased in the recent decades because its peak was much higher than that of any other countries during the recent decades (Fig. 3B).

Figure S1 shows trends of the number of newly registered clinical trials over time (years); it indicates that the number of newly registered clinical trials rose from below 10 at 20 years previously to approximately 70 in recent years. Figure S2 shows the relative proportion of new clinical trials registered on the ClinicalTrials.gov database, according to the five different locations.

#### Clinical trials investigating the effects of drugs or biologics

We evaluated the specific agents tested in 3 or more clinical trials; 14 agents were finally included. Bupivacaine, a local anesthetic, was tested in up to 25 clinical trials related to hip fractures; this was followed ropivacaine, another local anesthetic which was investigated in 23 clinical trials, and tranexamic acid, a hemostatic which was tested in 21 clinical trials. More details are shown in Table 2. Regarding the function of the 14 agents, 4 were anti-osteoporotic, 3 were local anesthetics, and 2 were pain killers. Notably, the majority of local anesthetics used in the trials aimed at alleviating pain.

#### Risk factors associated with recruitment status

On categorizing the recruitment status into completed vs. others categories, univariate analysis showed that NIH funding ($P<0.01$), interventions involving behavioral aspects ($P=0.04$), and locations other than China ($P=0.02$) were significantly associated with a higher rate of successfully completed recruitment (Table 3). In addition, clinical trials of a later phase tended to have a lower complete recruitment rate; however, this did not reach statistical significance ($P=0.07$). On multivariate analysis, trials including children as participants ($P=0.03$) and NIH funding ($P<0.01$) had significantly higher rates of complete recruitment. In particular, clinical trials involving children were twice as more likely to complete recruitment than those not involving children. Clinical trials funded by the NIH were 8.71 times more likely to complete recruitment than those not funded by the NIH.

On categorizing the recruitment status into seven subtypes, multivariate analysis showed that the outcome measures including mortality ($P=0.04$), phase ($P=0.01$), enrollment ($P=0.02$), allocation ($P=0.05$), diagnostic studies ($P=0.04$), and location in the United States ($P<0.01$) were significantly associated with recruitment status (Table S1). The distribution of recruitment status among outcome measures including mortality ($P=0.02$), phases ($P=0.01$), enrollment ($P<0.01$), and location in the United States ($P<0.01$) was also significantly different. More details are shown in Table S2.

#### Risk factors associated with completion time

On multiple Cox regression, enrollment (hazard ratio [HR] = 0.77, 95% CI: 0.70–0.84, $P<0.01$), being funded by the NIH (HR = 0.47, 95% CI: 0.28–0.82, $P=0.01$), studies testing drugs/biologics (HR = 1.48, 95% CI: 1.07–2.05, $P=0.02$), location in the United States (HR = 0.63, 95% CI: 0.46–0.87, $P<0.01$), and location in Europe (HR = 0.62, 95% CI: 0.48–0.81, $P<0.01$) were significantly relevant to completion time (Table 4). Higher enrollment ($P<0.01$, log-rank test, Fig. 4A), being funded by the NIH ($P<0.01$, log-rank test, Fig. 4B), location in the United States ($P=0.04$, log-rank test, Fig. 4D), and location in Europe ($P=0.03$, log-rank test, Fig. 4E) tended to prolong completion time, while studies involving drugs/biologics ($P<0.01$, log-rank test, Fig. 4C) were associated with a shorter completion time. Similar results were obtained when subgroup analysis was performed after excluding studies having an estimated completion date. Enrollment ($P<0.01$), being funded by the NIH ($P=0.01$), location in the United States ($P=0.02$), and location in Europe ($P<0.01$) retained significance; however, studies involving drugs/biologics ($P=0.07$) lost significance and location in Canada ($P=0.04$) became significant. However, the log-rank test showed that location in Canada did not have significance ($P=0.95$, log-rank test, Fig. 4F).

**Table 1** Characteristics of clinical trials relating to hip fractures

| Characteristics | Samples ($n=470$) |
|---|---|
| Recruitment status | |
| Completed | 44.89% (211/470) |
| Others | 55.11% (259/470) |
| Recruitment status | |
| Not yet recruiting | 6.81% (32/470) |
| Recruiting | 15.11% (71/470) |
| Enrolling by invitation | 1.49% (7/470) |
| Active, not recruiting | 3.83% (18/470) |
| Suspended | 9.57% (45/470) |
| Completed | 44.89% (211/470) |
| Unknown | 18.30% (86/470) |
| Study results | |
| No Results Available | 91.06% (428/470) |
| Has Results | 8.94% (42/470) |
| Start date (years) | |
| ≦2010 years | 29.36% (138/470) |
| > 2010 years and ≦2016 years | 35.11% (165/470) |
| > 2016 years | 35.53% (167/470) |
| Outcome measures including mortality | |
| Yes | 17.02% (80/470) |
| No | 82.98% (390/470) |
| Gender | |
| Male | 0.85% (4/470) |
| Female | 3.19% (15/470) |
| Both | 95.96% (451/470) |
| Age including children | |
| Yes | 8.51% (40/470) |
| No | 91.49% (430/470) |
| Age including older adults | |
| Yes | 98.09% (461/470) |
| No | 1.91% (9/470) |
| Phases | |
| Not applicable | 67.02% (315/470) |
| Phase 1 | 0.85% (4/470) |
| Phase 2 | 5.74% (27/470) |
| Phase 3 | 10.43% (49/470) |
| Phase 4 | 15.96% (75/470) |
| Enrollment | |
| ≤ 50 | 26.38% (124/470) |
| > 50 and ≤ 100 | 26.81% (126/470) |
| > 100 and ≤ 200 | 22.55% (106/470) |
| > 200 and ≤ 400 | 14.47% (68/470) |
| > 400 | 9.79% (46/470) |
| Funded by the NIH | |
| Yes | 3.83% (18/470) |
| No | 96.17% (452/470) |
| Funded by industry | |
| Yes | 15.32% (72/470) |
| No | 84.68% (398/470) |
| Allocation | |
| Not applicable | 11.06% (52/470) |
| Non-randomized | 7.66% (36/470) |
| Randomized | 81.28% (382/470) |
| Intervention model | |
| Single | 16.60% (78/470) |
| Sequential | 0.64% (3/470) |
| Parallel | 77.23% (363/470) |
| Factorial | 1.91% (9/470) |
| Crossover | 3.62% (17/470) |
| Masking | |
| None | 39.57% (186/470) |
| Single | 26.60% (125/470) |
| Double | 17.66% (83/470) |
| Triple | 5.96% (28/470) |
| Quadruple | 10.21% (48/470) |
| Primary purpose | |
| Diagnostic | 3.40% (16/470) |
| Health service research | 2.77% (13/470) |
| Prevention | 15.74% (74/470) |
| Supportive care | 5.74% (27/470) |
| Treatment | 68.09% (320/470) |
| others | 4.26% (20/470) |
| Interventions | |
| Behavioral | 7.23% (34/470) |
| Drug/biological | 30.21% (142/470) |
| Device | 24.47% (115/470) |
| Procedure | 28.09% (132/470) |
| Others | 10.00% (47/470) |
| Locations | |
| China | 9.36% (44/470) |
| United States | 21.28% (100/470) |
| Europe | 41.70% (196/470) |
| Canada | 6.60% (31/470) |
| Others | |
| Completion time (median, 95% CI, days) | 931.00 (822.56–1039.44) |

*NIH* National Institutes of Health, *CI* Confidence intervals

### Risk factors associated with successful trial completion (having results on the ClinicalTrials.gov website)

On the basis of multiple logistic regression analysis, enrollment ($P=0.04$), being funded by the NIH ($P=0.02$), being funded by industry ($P<0.01$), drug/biological therapy ($P=0.03$), and location in the United States ($P<0.01$) were significantly associated with successful trial completion (Table 5). In particular, smaller enrollment numbers, being funded by the NIH or industry, involving drugs/biologics, and location in the United States were associated with a higher rate of successful

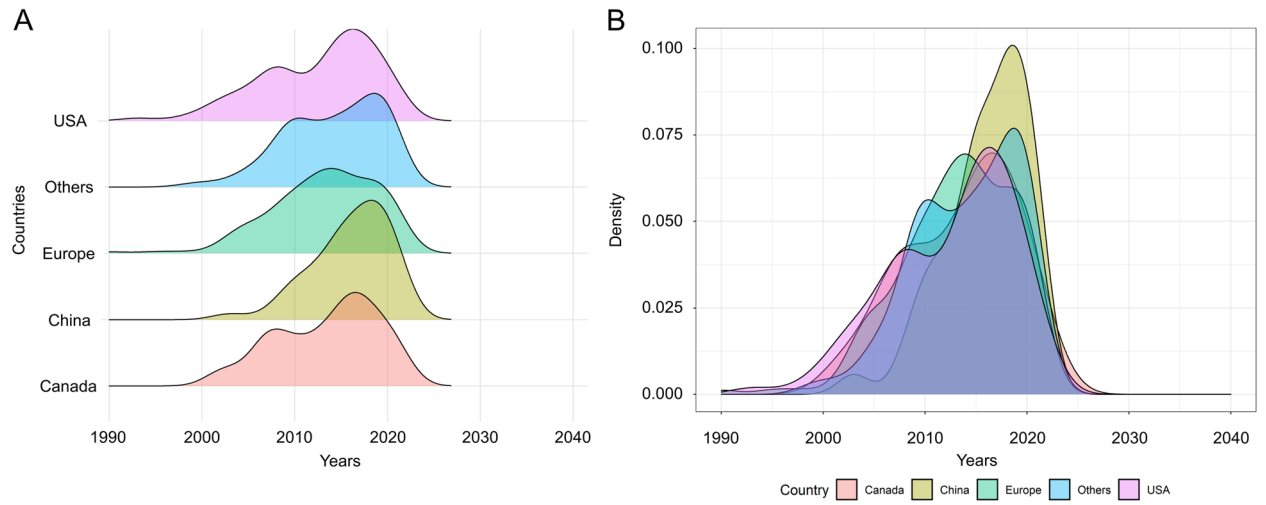


**Fig. 3** Density curve for clinical trials related to hip fracture registered at ClinicalTrials.gov. **a** Density curve with years plotted against the five areas (the United States of America [USA], Europe [Europ], China, Canada, and others); **b** Density curve with years plotted against the proportions in each area

**Table 2** Drugs or biologics investigated in clinical trials related to hip fractures

| Drugs | Classifications | Number of clinical trials[a] |
|---|---|---|
| Bupivacaine | Local anesthetic | 25 |
| Ropivacaine | Local anesthetic | 23 |
| Tranexamic acid | Hemostatic | 21 |
| Fentanyl | Pain killer | 9 |
| Vitamin D | Anti-osteoporotic | 8 |
| Morphine | Pain killer | 7 |
| Teriparatide | Anti-osteoporotic | 6 |
| Dexmedetomidine | α2-adrenergic receptor agonist | 4 |
| Risedronate | Anti-osteoporotic | 4 |
| Lidocaine | Local anesthetic | 4 |
| enoxaparin | Antithrombotic agent | 4 |
| Sevoflurane | Inhalation anesthetic | 4 |
| Propofol | General anesthetic | 4 |
| Testosterone | Anti-osteoporotic | 3 |

[a] Drugs investigated in three or more clinical trials are included in the table

trial completion. To investigate the predictive performance of the five mentioned significant variables, their AUROCs were calculated.

The AUROCs for enrollment alone (Fig. 5A), being funded by the NIH alone (Fig. 5B), being funded by industry alone (Fig. 5C), drug/biological therapy alone (Fig. 5D), and location in the United States alone (Fig. 5E) were 0.55, 0.56, 0.64, 0.66, and 0.76, respectively. On combining the five variables, the total AUROC rose to 0.86 (Fig. 5F), indicating favorable prediction performance of these variables.

## Discussion

Our study presented and summarized the data from clinical trials related to hip fractures and found that 44.89% (211/470) of the included trials had already completed recruitment; the overall median completion time was approximately 2.6 years. This number was relatively higher than that reported in other studies. In 2018, DePasse et al. [6] reported the completion rate of spinal cord injury trials registered at ClinicalTrials.gov to be 39.9%. After analyzing 97 clinical trials related to the use of artificial intelligence in the diagnosis of cancers in 2020, Dong et al. [9] found the trial completion rate to be 15.4%. In 2012, Califf et al. [10] analyzed the data from 96,346 clinical studies registered between 2007 and 2010; they found the completion rate to be 29.9%. Heterogeneity of the completion rates may be explained by wide variability in the diseases, advancement of technologies, and registered dates.

However, only 8.94% (42/470) of clinical trials in our study had published results on the ClinicalTrials.gov website; this indicates that it is necessary to improve transparency of trial data reporting, irrespective of positive or negative results. In this context, studies have demonstrated that researchers are more likely to report positive results [11]. Notably, improved prospective registration and consistent reporting of results on the ClinicalTrials.gov website will help the public find reliable information and avoid potential bias [12]. Our study found that smaller enrollment numbers, being funded by the NIH or industry, use of drugs/biologics, and

**Table 3** Univariate and multivariate analyses of characteristics for completion of recruitment in clinical trials related to hip fractures

| Characteristics | Completion rates | Simple logistic regression | | Multiple logistic regression | |
|---|---|---|---|---|---|
| | | OR (95% CI) | P | OR (95% CI) | P |
| Outcome measures including mortality | | | | | |
| Yes | 45.00% (36/80) | 1.01 (0.62–1.63) | 0.98 | 0.97 (0.56–1.68) | 0.91 |
| No | 44.87% (175/390) | | | | |
| Gender | | | | | |
| Male | 75.00% (3/4) | 0.99 (0.40–2.45) | 0.98 | 1.48 (0.51–4.32) | 0.47 |
| Female | 53.33% (8/15) | | | | |
| Both | 44.35% (200/451) | | | | |
| Age including children | | | | | |
| Yes | 57.50% (23/40) | 1.74 (0.90–3.35) | 0.10 | 2.27 (1.11–4.68) | 0.03 |
| No | 43.72% (188/430) | | | | |
| Age including older adults | | | | | |
| Yes | 45.34% (209/461) | 2.90 (0.60–14.12) | 0.19 | 3.45 (0.62–19.26) | 0.16 |
| No | 22.22% (2/9) | | | | |
| Phases | | | | | |
| Not applicable | 40.63% (128/315) | 1.11 (0.99–1.24) | 0.07 | 1.10 (0.94–1.28) | 0.22 |
| Phase 1 | 50.00% (2/4) | | | | |
| Phase 2 | 70.37% (19/27) | | | | |
| Phase 3 | 61.22% (30/49) | | | | |
| Phase 4 | 42.67% (32/75) | | | | |
| Enrollment | | | | | |
| $\leq 50$ | 43.55% (54/124) | 1.02 (0.88–1.17) | 0.82 | 0.98 (0.82–1.15) | 0.76 |
| $>50$ and $\leq 100$ | 42.86% (54/126) | | | | |
| $>100$ and $\leq 200$ | 47.17% (50/106) | | | | |
| $>200$ and $\leq 400$ | 54.41% (37/68) | | | | |
| $>400$ | 34.78% (16/46) | | | | |
| Funded by the NIH | | | | | |
| Yes | 83.33% (15/18) | 6.53 (1.86–22.87) | $<0.01$ | 8.71 (2.13–35.61) | $<0.01$ |
| No | 43.36% (196/452) | | | | |
| Funded by industry | | | | | |
| Yes | 50.00% (36/72) | 1.27 (0.77–2.11) | 0.34 | 1.61 (0.92–2.84) | 0.10 |
| No | 43.97% (175/398) | | | | |
| Allocation | | | | | |
| Not applicable | 32.69% (17/52) | 1.25 (0.94–1.66) | 0.13 | 1.28 (0.80–2.05) | 0.31 |
| Non-randomized | 50.00% (18/36) | | | | |
| Randomized | 46.07% (176/382) | | | | |
| Intervention model | | | | | |
| Single | 42.31% (33/78) | 1.09 (0.89–1.35) | 0.39 | 1.07 (0.78–1.49) | 0.67 |
| Sequential | 0.00% (0/3) | | | | |
| Parallel | 45.18% (164/363) | | | | |
| Factorial | 66.67% (6/9) | | | | |
| Crossover | 47.06% (8/17) | | | | |
| Masking | | | | | |
| None | 44.09% (82/186) | 1.01 (0.88–1.17) | 0.86 | 0.86 (0.71–1.03) | 0.10 |
| Single | 45.60% (57/125) | | | | |
| Double | 45.78% (38/83) | | | | |
| Triple | 42.86% (12/28) | | | | |
| Quadruple | 45.83% (22/48) | | | | |
| Primary purpose | | | | | |

**Table 3** (continued)

| Characteristics | Completion rates | Simple logistic regression | | Multiple logistic regression | |
|---|---|---|---|---|---|
| | | OR (95% CI) | P | OR (95% CI) | P |
| Diagnostic | | | | | |
| Yes | 25.00% (4/16) | 0.40 (0.13–1.25) | 0.12 | 0.72 (0.16–3.23) | 0.67 |
| No | 45.59% (207/454) | | | | |
| Health service research | | | | | |
| Yes | 46.15% (6/13) | 1.05 (0.35–3.18) | 0.93 | 1.17 (0.27–5.07) | 0.83 |
| No | 44.86% (205/457) | | | | |
| Prevention | | | | | |
| Yes | 40.54% (30/74) | 0.81 (0.49–1.34) | 0.41 | 0.80 (0.27–2.38) | 0.69 |
| No | 45.71% (181/396) | | | | |
| Supportive care | | | | | |
| Yes | 44.44% (12/27) | 0.98 (0.45–2.14) | 0.96 | 0.90 (0.26–3.13) | 0.87 |
| No | 44.92% (199/443) | | | | |
| Treatment | | | | | |
| Yes | 47.19% (151/320) | 1.34 (0.90–1.99) | 0.14 | 1.22 (0.46–3.27) | 0.69 |
| No | 40.00% (60/150) | | | | |
| Interventions | | | | | |
| Behavioral | | | | | |
| Yes | 61.76% (21/34) | 2.09 (1.02–4.28) | 0.04 | 1.56 (0.67–3.64) | 0.31 |
| No | 43.58% (190/436) | | | | |
| Drug/biological agent | | | | | |
| Yes | 50.00% (71/142) | 1.34 (0.91–1.99) | 0.14 | 1.11 (0.60–2.05) | 0.75 |
| No | 42.68% (140/328) | | | | |
| Device | | | | | |
| Yes | 38.26% (44/115) | 0.70 (0.45–1.07) | 0.10 | 0.65 (0.38–1.13) | 0.13 |
| No | 47.04% (167/355) | | | | |
| Procedure | | | | | |
| Yes | 40.91% (54/132) | 0.80 (0.53–1.20) | 0.28 | 0.86 (0.52–1.40) | 0.54 |
| No | 46.45% (157/338) | | | | |
| Location in China | | | | | |
| Yes | 27.27% (12/44) | 0.43 (0.22–0.85) | 0.02 | 0.51 (0.23–1.15) | 0.10 |
| No | 46.71% (199/426) | | | | |
| Location in the United States | | | | | |
| Yes | 49.00% (49/100) | 1.23 (0.79–1.92) | 0.35 | 0.82 (0.43–1.54) | 0.53 |
| No | 43.78% (162/370) | | | | |
| Location in Europe | | | | | |
| Yes | 47.45% (93/196) | 1.19 (0.83–1.73) | 0.35 | 1.09 (0.66–1.82) | 0.73 |
| No | 43.07% (118/274) | | | | |
| Location in Canada | | | | | |
| Yes | 45.16% (14/31) | 1.01 (0.49–2.10) | 0.98 | 0.97 (0.41–2.28) | 0.94 |
| No | 44.87% (197/439) | | | | |

*NIH* National Institutes of Health, *OR* Odds ratio, *CI* Confidence intervals

location in the United States were associated with a higher rate of successful trial completion on the ClinicalTrial.gov website. Smaller enrollment numbers appeared to be associated with a higher completion rate and shorter completion time; this may have increased the likelihood of presentation of results. Clinical trials being funded by the NIH or industry may need to abide by strict laws, policies, and scientific norms/practices, as these trials are relatively large and of a multinational design. Various incentives and rules may influence the trial components [13].

**Table 4** Univariate and multivariate analyses of characteristics for completion time in clinical trials related to hip fractures

| Characteristics | Completion time (median, days) | Simple Cox regression | | Multiple Cox regression | | Multiple Cox regression[a] | |
|---|---|---|---|---|---|---|---|
| | | HR (95% CI) | P | HR (95% CI) | P | HR (95% CI) | P |
| Outcome measures including mortality | | | | | | | |
| Yes | 1430.00 | 0.66 (0.52–0.84) | < 0.01 | 0.89 (0.67–1.17) | 0.40 | 0.83 (0.57–1.22) | 0.34 |
| No | 823.00 | | | | | | |
| Gender | | | | | | | |
| Male | 122.00 | 1.42 (0.89–2.26) | 0.13 | 1.05 (0.67–1.66) | 0.83 | 0.87 (0.47–1.64) | 0.67 |
| Female | 1065.00 | | | | | | |
| Both | 931.00 | | | | | | |
| Age including children | | | | | | | |
| Yes | 882.00 | 0.97 (0.70–1.34) | 0.84 | 1.00 (0.70–1.43) | 1.00 | 0.83 (0.52–1.34) | 0.45 |
| No | 945.00 | | | | | | |
| Age including older adults | | | | | | | |
| Yes | 931.00 | 1.00 (0.51–1.93) | 0.99 | 1.56 (0.74–3.27) | 0.24 | 0.87 (0.24–3.18) | 0.83 |
| No | 1096.00 | | | | | | |
| Phases | | | | | | | |
| Not applicable | 973.00 | 1.09 (1.03–1.16) | < 0.01 | 1.06 (0.98–1.14) | 0.16 | 1.07 (0.96–1.19) | 0.22 |
| Phase 1 | 360.00 | | | | | | |
| Phase 2 | 1055.00 | | | | | | |
| Phase 3 | 1036.00 | | | | | | |
| Phase 4 | 731.00 | | | | | | |
| Enrollment | | | | | | | |
| ≤ 50 | 671.00 | 0.76 (0.71–0.82) | < 0.01 | 0.77 (0.70–0.84) | < 0.01 | 0.80 (0.71–0.90) | < 0.01 |
| > 50 and ≤ 100 | 725.00 | | | | | | |
| > 100 and ≤ 200 | 1096.00 | | | | | | |
| > 200 and ≤ 400 | 1308.00 | | | | | | |
| > 400 | 1646.00 | | | | | | |
| Funded by the NIH | | | | | | | |
| Yes | 2007.00 | 0.44 (0.27–0.70) | < 0.01 | 0.47 (0.28–0.82) | 0.01 | 0.41 (0.22–0.78) | 0.01 |
| No | 894.00 | | | | | | |
| Funded by industry | | | | | | | |
| Yes | 762.00 | 0.88 (0.69–1.14) | 0.33 | 0.96 (0.72–1.28) | 0.79 | 1.09 (0.74–1.60) | 0.66 |
| No | 945.00 | | | | | | |
| Allocation | | | | | | | |
| Not applicable | 700.00 | 0.92 (0.80–1.06) | 0.27 | 0.92 (0.72–1.18) | 0.52 | 0.91 (0.65–1.28) | 0.59 |
| Non-randomized | 851.00 | | | | | | |
| Randomized | 1003.00 | | | | | | |
| Intervention model | | | | | | | |
| Single | 819.00 | 1.01 (0.91–1.13) | 0.83 | 1.13 (0.95–1.35) | 0.16 | 1.18 (0.93–1.49) | 0.18 |
| Sequential | 744.00 | | | | | | |
| Parallel | 1004.00 | | | | | | |
| Factorial | 1065.00 | | | | | | |
| Crossover | 365.00 | | | | | | |
| Masking | | | | | | | |
| None | 941.00 | 1.09 (1.01–1.17) | 0.02 | 1.00 (0.92–1.10) | 0.93 | 0.98 (0.87–1.11) | 0.75 |
| Single | 1037.00 | | | | | | |
| Double | 819.00 | | | | | | |
| Triple | 671.00 | | | | | | |
| Quadruple | 1055.00 | | | | | | |

**Table 4** (continued)

| Characteristics | Completion time (median, days) | Simple Cox regression | | Multiple Cox regression | | Multiple Cox regression[a] | |
|---|---|---|---|---|---|---|---|
| | | HR (95% CI) | P | HR (95% CI) | P | HR (95% CI) | P |
| Primary purpose | | | | | | | |
| Diagnostic | | | | | | | |
| Yes | 638.00 | 1.78 (1.08–2.94) | 0.04 | 1.35 (0.66–2.74) | 0.41 | 1.73 (0.60–5.00) | 0.31 |
| No | 950.00 | | | | | | |
| Health service research | | | | | | | |
| Yes | 950.00 | 0.98 (0.56–1.70) | 0.94 | 0.81 (0.39–1.70) | 0.58 | 0.62 (0.20–1.89) | 0.40 |
| No | 931.00 | | | | | | |
| Prevention | | | | | | | |
| Yes | 822.00 | 1.08 (0.85–1.39) | 0.53 | 1.01 (0.59–1.71) | 0.98 | 0.94 (0.44–2.01) | 0.88 |
| No | 1003.00 | | | | | | |
| Supportive care | | | | | | | |
| Yes | 747.00 | 1.24 (0.84–1.83) | 0.30 | 1.10 (0.60–2.02) | 0.76 | 0.88 (0.38–2.04) | 0.77 |
| No | 945.00 | | | | | | |
| Treatment | | | | | | | |
| Yes | 1047.00 | 0.83 (0.68–1.01) | 0.06 | 0.76 (0.46–1.24) | 0.26 | 0.75 (0.37–1.52) | 0.42 |
| No | 762.00 | | | | | | |
| Interventions | | | | | | | |
| Behavioral | | | | | | | |
| Yes | 882.00 | 0.96 (0.68–1.37) | 0.83 | 1.16 (0.78–1.72) | 0.46 | 0.95 (0.58–1.55) | 0.82 |
| No | 941.00 | | | | | | |
| Drug/biological | | | | | | | |
| Yes | 731.00 | 1.57 (1.28–1.92) | < 0.01 | 1.48 (1.07–2.05) | 0.02 | 1.50 (0.96–2.35) | 0.07 |
| No | 1035.00 | | | | | | |
| Device | | | | | | | |
| Yes | 1096.00 | 0.71 (0.58–0.88) | < 0.01 | 0.93 (0.70–1.24) | 0.63 | 0.91 (0.60–1.40) | 0.68 |
| No | 866.00 | | | | | | |
| Procedure | | | | | | | |
| Yes | 914.00 | 0.98 (0.80–1.20) | 0.83 | 1.07 (0.82–1.40) | 0.60 | 0.75 (0.50–1.14) | 0.17 |
| No | 931.00 | | | | | | |
| Location in China | | | | | | | |
| Yes | 866.00 | 1.25 (0.92–1.71) | 0.17 | 0.93 (0.64–1.34) | 0.68 | 0.56 (0.28–1.10) | 0.09 |
| No | 973.00 | | | | | | |
| Location in the United States | | | | | | | |
| Yes | 1125.00 | 0.79 (0.63–0.99) | 0.03 | 0.63 (0.46–0.87) | < 0.01 | 0.56 (0.35–0.90) | 0.02 |
| No | 882.00 | | | | | | |
| Location in Europe | | | | | | | |
| Yes | 1065.00 | 0.82 (0.68–0.98) | 0.03 | 0.62 (0.48–0.81) | < 0.01 | 0.51 (0.35–0.76) | < 0.01 |
| No | 821.00 | | | | | | |
| Location in Canada | | | | | | | |
| Yes | 931.00 | 1.09 (0.75–1.57) | 0.66 | 0.69 (0.45–1.05) | 0.08 | 0.54 (0.30–0.97) | 0.04 |
| No | 945.00 | | | | | | |

*NIH* National Institutes of Health, *HR* Hazard ratio, *CI* Confidence intervals

[a] indicates *P* values obtained from the analysis excluding estimated completion time

In clinical trials testing drugs/biologics for the prevention and treatment of hip fractures, the top three agents were bupivacaine (a local anesthetic, 25 clinical trials), ropivacaine (a local anesthetic, 23 clinical trials) and tranexamic acid (a hemostatic, 21 clinical trials). Regarding the pharmacological action of the agents appearing in 3 or more clinical trials, 4 of the 14 agents were anti-osteoporotic, 3 were local anesthetics, and 2 were

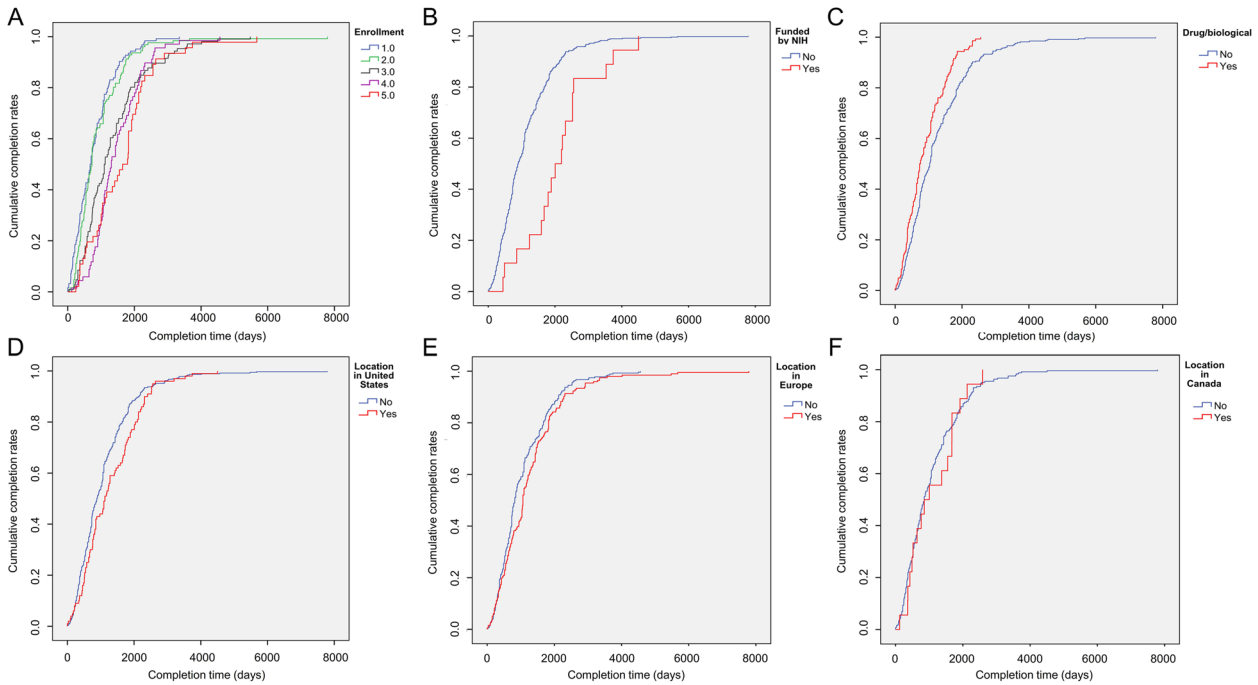


**Fig. 4** Cumulative completion curves. **a** Enrollment (1 indicates ≤ 50; 2 indicates > 50 and ≤ 100; 3 indicates > 100 and ≤ 200; 4 indicates > 200 and ≤ 400; and 5 indicates > 400; $P < 0.01$, log-rank test); **b** Funded by the National Institutes of Health ($P < 0.01$, log-rank test), **c** Interventions involving drugs/biologics ($P < 0.01$, log-rank test); **d** location in the United States ($P = 0.04$, log-rank test); **e** location in Europe ($P = 0.03$, log-rank test); f location in Canada ($P = 0.95$, log-rank test)

pain killers. We could not therefore conclude whether the majority of agents focused on anti-osteoporosis, pain alleviation, or hemostasis.

The findings of this study indicated that trials including children as participants ($P = 0.03$) and those funded by the NIH ($P < 0.01$) had a significantly higher likelihood of complete recruitment. In particular, clinical trials involving children were twice as likely to complete recruitment compared to those not involving children. Clinical trials funded by the NIH were 8.71 times more likely to have completed recruitment status as compared to those not funded by the NIH. However, clinical trials that were funded by the NIH also had longer completion time. The results therefore indicated that clinical trials that were funded by the NIH may have been relatively large and had strict requirements or processes. In addition, participants may have had more trust in these studies, and were more willing to participate. Therefore, clinical trials funded by the NIH needed more time to complete and had higher complete recruitment rates. Regarding subgroup analysis, outcome measures including mortality were associated with a higher recruitment rate (21.25% vs. 13.85%) and a lower suspension rate (5.00% vs. 10.51%); this indicated that clinical trials evaluating patient mortality were less likely to be stopped early, as adequate time was needed to measure patient survival outcomes. The 1-year mortality in some studies was found to be 26%-33% [14, 15], and the median overall survival of patients with hip fractures was 886 days [15]. This may also indicate that selection of mortality as an outcome was more likely to be associated with successful completion, although these trials needed more time to complete. A later phase of clinical trials tended to be associated with a lower completion rate; this could be explained by stricter rules and regulations in later phases. Enrollment of more than 200 and less than 400 participants was associated with the highest completion rate; this indicated that appropriate enrollment facilitated completion. This study also found that higher enrollment, being funded by the NIH, and location in the United States or Europe tended to prolong completion time, while the use of drugs/biologics was associated with shorter completion time. The above results suggested that an appropriate number of participants/sponsors and tested drugs facilitated completion. However, it is necessary to achieve a balance, as trials funded by the NIH and those performed in the United States may have been relatively large, requiring higher enrollment and completion time. In this context, industry-funded trials for rare diseases are less vulnerable to discontinuation than healthcare center-funded trials [16].

**Table 5** Univariate and multivariate analyses of characteristics for successful trial completion (having results on ClinicalTrials.gov)

| Characteristics | Rates | Simple logistic regression | | Multiple logistic regression | |
|---|---|---|---|---|---|
| | | OR (95% CI) | P | OR (95% CI) | P |
| Outcome measures including mortality | | | | | |
| Yes | 6.25% (5/80) | 0.64 (0.24–1.67) | 0.36 | 1.25 (0.35–4.49) | 0.73 |
| No | 9.49% (37/390) | | | | |
| Gender | | | | | |
| Male | 25.00% (1/4) | 2.08 (0.35–12.28) | 0.42 | 3.07 (0.42–22.46) | 0.27 |
| Female | 6.67% (1/15) | | | | |
| Both | 8.87% (40/451) | | | | |
| Age including children | | | | | |
| Yes | 5.00% (2/40) | 0.51 (0.12–2.21) | 0.37 | 1.30 (0.22–7.63) | 0.77 |
| No | 9.30% (40/430) | | | | |
| Age including older adults | | | | | |
| Yes | 8.89% (41/461) | 0.78 (0.10–6.40) | 0.82 | 0.96 (0.08–11.59) | 0.97 |
| No | 11.11% (1/9) | | | | |
| Phases | | | | | |
| Not applicable | 5.71% (18/315) | 1.30 (1.08–1.55) | < 0.01 | 1.05 (0.77–1.44) | 0.74 |
| Phase 1 | 0.00% (0/4) | | | | |
| Phase 2 | 25.93% (7/27) | | | | |
| Phase 3 | 16.33% (8/49) | | | | |
| Phase 4 | 12.00% (9/75) | | | | |
| Enrollment | | | | | |
| ≤ 50 | 12.90% (16/124) | 0.89 (0.69–1.15) | 0.39 | 0.71 (0.51–0.99) | 0.04 |
| > 50 and ≤ 100 | 7.14% (9/126) | | | | |
| > 100 and ≤ 200 | 6.60% (7/106) | | | | |
| > 200 and ≤ 400 | 7.35% (5/68) | | | | |
| > 400 | 10.87% (5/46) | | | | |
| Funded by the NIH | | | | | |
| Yes | 33.33% (6/18) | 5.78 (2.05–16.31) | < 0.01 | 7.55 (1.48–38.56) | 0.02 |
| No | 7.96% (36/452) | | | | |
| Funded by industry | | | | | |
| Yes | 23.61% (17/72) | 4.61 (2.34–9.09) | < 0.01 | 6.32 (2.43–16.44) | < 0.01 |
| No | 6.28% (25/398) | | | | |
| Allocation | | | | | |
| Not applicable | 1.92% (1/52) | 1.53 (0.82–2.85 | 0.18 | 1.28 (0.42–3.92) | 0.66 |
| Non-randomized | 13.89% (5/36) | | | | |
| Randomized | 9.42% (36/382) | | | | |
| Intervention model | | | | | |
| Single | 3.85% (3/78) | 1.30 (0.89–1.91) | 0.18 | 1.54 (0.76–3.10) | 0.23 |
| Sequential | 0.00% (0/3) | | | | |
| Parallel | 10.19% (37/363) | | | | |
| Factorial | 11.11% (1/9) | | | | |
| Crossover | 5.88% (1/17) | | | | |
| Masking | | | | | |
| None | 9.68% (18/186) | 1.24 (0.99–1.56) | 0.06 | 0.83 (0.59–1.17) | 0.28 |
| Single | 4.80% (6/125) | | | | |
| Double | 3.61% (3/83) | | | | |
| Triple | 21.43% (6/28) | | | | |
| Quadruple | 18.75% (9/48) | | | | |

**Table 5** (continued)

| Characteristics | Rates | Simple logistic regression | | Multiple logistic regression | |
|---|---|---|---|---|---|
| | | OR (95% CI) | P | OR (95% CI) | P |
| Primary purpose | | | | | |
| Diagnostic | | | | | |
| Yes | 6.25% (1/16) | 0.67 (0.09–5.21) | 0.70 | 0.41 (0.01–24.96) | 0.67 |
| No | 9.03% (41/454) | | | | |
| Health service research | | | | | |
| Yes | 0.00% (0/13) | 0.01 (0.00–99.99) | 0.98 | 0.01 (0.00–99.99) | 0.98 |
| No | 9.19% (42/457) | | | | |
| Prevention | | | | | |
| Yes | 13.51% (10/74) | 1.78 (0.83–3.79) | 0.14 | 1.20 (0.10–14.56) | 0.89 |
| No | 8.08% (32/396) | | | | |
| Supportive care | | | | | |
| Yes | 0.00% (0/27) | 0.01 (0.00–99.99) | 0.98 | 0.01 (0.00–99.99) | 0.98 |
| No | 9.48% (42/443) | | | | |
| Treatment | | | | | |
| Yes | 9.38% (30/320) | 1.19 (0.59–2.39) | 0.63 | 0.70 (0.07–7.40) | 0.77 |
| No | 8.00% (12/150) | | | | |
| Interventions | | | | | |
| Behavioral | | | | | |
| Yes | 2.94% (1/34) | 0.29 (0.04–2.19) | 0.23 | 0.18 (0.01–2.52) | 0.20 |
| No | 9.40% (41/436) | | | | |
| Drug/biological | | | | | |
| Yes | 17.61% (25/142) | 3.91 (2.04–7.50) | < 0.01 | 4.47 (1.19–16.83) | 0.03 |
| No | 5.18% (17/328) | | | | |
| Device | | | | | |
| Yes | 12.17% (14/115) | 1.62 (0.82–3.19) | 0.16 | 2.53 (0.77–8.29) | 0.12 |
| No | 7.89% (28/355) | | | | |
| Procedure | | | | | |
| Yes | 4.55% (6/132) | 0.40 (0.16–0.97) | 0.04 | 0.99 (0.34–2.90) | 0.99 |
| No | 10.65% (36/338) | | | | |
| Location in China | | | | | |
| Yes | 4.55% (2/44) | 0.46 (0.11–1.97) | 0.30 | 1.91 (0.26–13.86) | 0.52 |
| No | 9.39% (40/426) | | | | |
| Location in the United States | | | | | |
| Yes | 29.00% (29/100) | 11.22 (5.56–22.63) | < 0.01 | 9.43 (2.41–36.95) | < 0.01 |
| No | 3.51% (13/370) | | | | |
| Location in Europe | | | | | |
| Yes | 3.06% (6/196) | 0.21 (0.09–0.51) | < 0.01 | 0.89 (0.20–4.00) | 0.88 |
| No | 13.14% (36/274) | | | | |
| Location in Canada | | | | | |
| Yes | 6.45% (2/31) | 0.69 (0.16–2.99) | 0.62 | 1.96 (0.25–15.67) | 0.53 |
| No | 9.11% (40/439) | | | | |

*OR* Odds rates, *NIH* National Institutes of Health, *CI* Confidence intervals

### Limitations

The present study has certain limitations. Firstly, ClinicalTrials.gov did not include all the clinical trials worldwide; this may limit the generalization of our results to other aspects and areas. Nonetheless, ClinicalTrials.gov has already registered over 80% of all clinical trials on the World Health Organization platform [17]. Secondly, missing and incomplete data may have led to potential bias [18]; however, as the present study excluded clinical studies with missing data, bias may have been largely

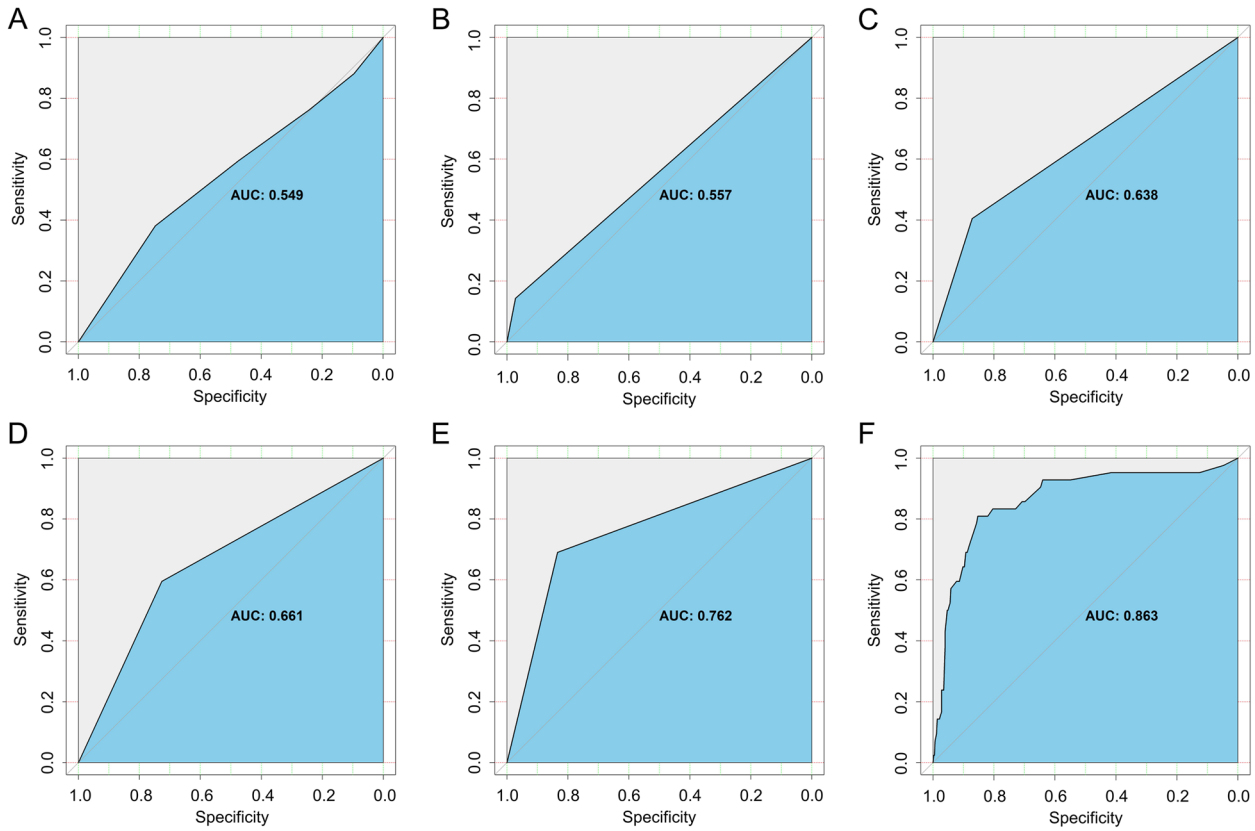


**Fig. 5** The area under the receiver operating characteristic (AUROC) for the five significant variables associated with successful trial completion (having results on the ClinicalTrial.gov website). **a** Enrollment alone; **b** Funded by the National Institutes of Health alone; **c** Funded by industry alone; **d** Interventions involving drug/biological agents alone; **e** Location in the United States alone; **f** Combination of the five variables

avoided. Lastly, dynamic changes of data always exist over time, and this study had a cross-sectional design. However, our study analyzed all data from clinical trials related to hip fractures over the past 20 years; it therefore reflected the trend of developments and advancements among patients with hip fractures. Nevertheless, future investigations will be needed.

## Conclusions

Although a considerable number of clinical trials related to hip fractures have been completed, the results of only a small fraction have been presented on the ClinicalTrials.gov website. The commonly investigated drugs focus on anesthesia, pain relief, and hemostasis. Several independent risk factors have been identified to affect the recruitment status and completion time; these may guide the design of clinical trials related to hip fractures.

### Abbreviations

AUROC: Area under the receiver operating characteristics curve; NIH: National Institutes of Health; CI: Confidence intervals; HR: Hazard ratio; OR: Odds ratio.

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12891-022-05714-x.

**Additional file 1.**

**Additional file 2.**

**Additional file 3.**

**Additional file 4.**

### Acknowledgements

None.

### Authors' contributions

SW and ML contributed to the design and conception of the study. YG and XZ participated in the acquisition and analysis of data. SW, FX, and ML drafted the manuscript, contributed to data interpretation, and were involved in drafting and revising of the manuscript. All authors collaborated to interpret data, revise the work critically for important intellectual content, and approve the final version of the manuscript.

### Funding

None.

### Availability of data and materials

All data were publicly available at https://clinicaltrials.gov/.

## Declarations

### Ethics approval and consent to participate

As the study analyzed existing publicly available data, patients were not actively recruited for data collection. The Ethics Committee Board of the Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University waived the need for informed consent, as all data were publicly available at https://clinicaltrials.gov/. This study adhered to the principles of the Declaration of Helsinki.

### Consent for publication

Not applicable.

### Competing of interest

The authors declare that they have no competing interests.

### Author details

[1]Department of Orthopaedic Surgery, Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University, Yishan Road 600#, Shanghai 200233, China. [2]Department of Orthopedic Surgery, People's Hospital of Macheng City, Huang Gang 438399, China. [3]Department of Orthopaedic Surgery, Henan Provincial People's Hospital, Zhengzhou 450003, China. [4]Chinese PLA Medical School, 28 Fuxing Road, Beijing 100853, China. [5]Department of Orthopedic Surgery, Hainan Hospital of PLA General Hospital, Sanya, China. [6]The National Clinical Research Center for Orthopedics, Sports Medicine & Rehabilitation, PLA General Hospital, Beijing, China.

Received: 30 December 2021 Accepted: 28 July 2022
Published online: 16 August 2022

### References

1. Veronese N, Maggi S. Epidemiology and social costs of hip fracture. Injury. 2018;49:1458–60.
2. Rapp K, Buchele G, Dreinhofer K, Bucking B, Becker C, Benzinger P. Epidemiology of hip fractures: systematic literature review of German data and an overview of the international literature. Z Gerontol Geriatr. 2019;52:10–6.
3. Gandhi R, Jan M, Smith HN, Mahomed NN, Bhandari M. Comparison of published orthopaedic trauma trials following registration in Clinicaltrials.gov. BMC Musculoskelet Disord. 2011;12:278.
4. Ehrhardt S, Appel LJ, Meinert CL. Trends in national institutes of health funding for clinical trials registered in ClinicalTrials.gov. JAMA. 2015;314:2566–7.
5. Ohnmeiss DD. The fate of prospective spine studies registered on www.ClinicalTrials.gov. Spine J. 2015;15:487–91.
6. DePasse JM, Park S, Eltorai AEM, Daniels AH. Factors predicting publication of spinal cord injury trials registered on www.ClinicalTrials.gov. J Back Musculoskelet Rehabil. 2018;31:45–8.
7. Khan NA, Singh M, Spencer HJ, Torralba KD. Randomized controlled trials of rheumatoid arthritis registered at ClinicalTrials.gov: what gets published and when. Arthritis Rheumatol. 2014;66:2664–74.
8. Chahal J, Tomescu SS, Ravi B, Bach BR Jr, Ogilvie-Harris D, Mohamed NN, et al. Publication of sports medicine-related randomized controlled trials registered in ClinicalTrials.gov. Am J Sports Med. 2012;40:1970–7.
9. Dong J, Geng Y, Lu D, Li B, Tian L, Lin D, et al. Clinical trials for artificial intelligence in cancer diagnosis: a cross-sectional study of registered trials in ClinicalTrials.gov. Front Oncol. 2020;10:1629.
10. Califf RM, Zarin DA, Kramer JM, Sherman RE, Aberle LH, Tasneem A. Characteristics of clinical trials registered in ClinicalTrials.gov, 2007–2010. JAMA. 2012;307:1838–47.
11. Odutayo A, Emdin CA, Hsiao AJ, Shakir M, Copsey B, Dutton S, et al. Association between trial registration and positive study findings: cross sectional study (Epidemiological Study of Randomized Trials-ESORT). BMJ. 2017;356: j917.
12 Adam GP, Springs S, Trikalinos T, Williams JW Jr, Eaton JL, Von Isenburg M, et al. Does information from ClinicalTrials.gov increase transparency and reduce bias? Results from a five-report case series. Syst Rev. 2018;7:59.
13 Tse T, Fain KM, Zarin DA. How to avoid common problems when using ClinicalTrials.gov in research: 10 issues to consider. BMJ. 2018;361:k1452.
14. Mattisson L, Bojan A, Enocson A. Epidemiology, treatment and mortality of trochanteric and subtrochanteric hip fractures: data from the Swedish fracture register. BMC Musculoskelet Disord. 2018;19:369.
15. Guzon-Illescas O, Perez Fernandez E, Crespi Villarias N, Quiros Donate FJ, Pena M, Alonso-Blas C, et al. Mortality after osteoporotic hip fracture: incidence, trends, and associated factors. J Orthop Surg Res. 2019;14:203.
16. Rees CA, Pica N, Monuteaux MC, Bourgeois FT. Noncompletion and nonpublication of trials studying rare diseases: A cross-sectional analysis. PLoS Med. 2019;16:e1002966.
17. Zarin DA, Ide NC, Tse T, Harlan WR, West JC, Lindberg DA. Issues in the registration of clinical trials. JAMA. 2007;297:2112–20.
18 Chaturvedi N, Mehrotra B, Kumari S, Gupta S, Subramanya HS, Saberwal G. Some data quality issues at ClinicalTrials.gov. Trials. 2019;20:378.

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Ready to submit your research? Choose BMC and benefit from:**

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

**At BMC, research is always in progress.**

**Learn more** biomedcentral.com/submissions