

# Waiting time for hip fracture surgery: hospital variation, causes, and effects on postoperative mortality

DATA ON 37,708 OPERATIONS REPORTED TO THE NORWEGIAN HIP FRACTURE REGISTER FROM 2014 TO 2018



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## Aims

This study aimed to describe preoperative waiting times for surgery in hip fracture patients in Norway, and analyze factors affecting waiting time and potential negative consequences of prolonged waiting time.

## Methods

Overall, 37,708 hip fractures in the Norwegian Hip Fracture Register from January 2014 to December 2018 were linked with data in the Norwegian Patient Registry. Hospitals treating hip fractures were characterized according to their hip fracture care. Waiting time (hours from admission to start of surgery), surgery within regular working hours, and surgery on the day of or on the day after admission, i.e. 'expedited surgery' were estimated.

## Results

Mean waiting time was 22.6 hours (SD 20.7); 36,652 patients (97.2%) waited less than three days (< 72 hours), and 27,527 of the patients (73%) were operated within regular working hours (08:00 to 16:00). Expedited surgery was given to 31,675 of patients (84%), and of these, 19,985 (53%) were treated during regular working hours. Patients classified as American Society of Anesthesiologists (ASA) classes 4 and 5 were more likely to have surgery within regular working hours (odds ratio (OR) 1.59;  $p < 0.001$ ), and less likely to receive expedited surgery than ASA 1 patients (OR 0.29;  $p < 0.001$ ). Low-volume hospitals treated a larger proportion of patients during regular working hours than high volume hospitals (OR 1.26;  $p < 0.001$ ). High-volume hospitals had less expedited surgery and significantly longer waiting times than low and intermediate-low volume hospitals. Higher ASA classes and Charlson Comorbidity Index increased waiting time. Patients not receiving expedited surgery had higher 30-day and one-year mortality rates (OR 1.19;  $p < 0.001$ ) and OR 1.13;  $p < 0.001$ ), respectively.

## Conclusion

There is inequality in waiting time for hip fracture treatment in Norway. Variations in waiting time from admission to hip fracture surgery depended on both patient and hospital factors. Not receiving expedited surgery was associated with increased 30-day and one-year mortality rates.

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## Introduction

A hip fracture in elderly people is associated with a substantially increased risk of death compared to the general population, and with subsequent 30-day mortality of around 8%.<sup>1</sup>

Prolonged waiting time from fracture to surgery increases mortality.<sup>2,3</sup> On the other hand, accelerated surgery within six hours of diagnosis did not reduce postoperative mortality.<sup>4</sup> Pincus et

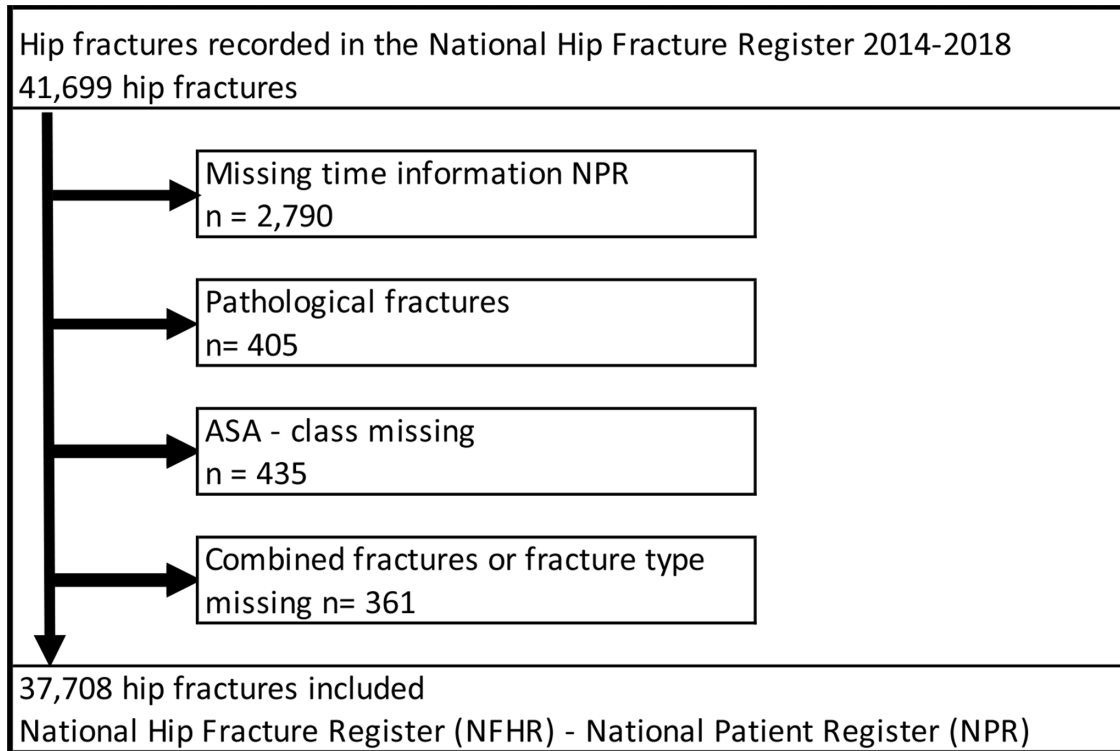


Fig. 1

Flow chart patient selection Hip fractures recorded in the National Hip Fracture Register from 2014 to 2018.

al<sup>2</sup> identified a potential threshold for defining higher risk related to waiting time at 24 hours.

Evidence-based guidelines from the National Institute of Health and Care Excellence (NICE) and the American Academy of Orthopaedic Surgeons recommend the shortest possible waiting time,<sup>5,6</sup> and advocate performing surgery within 36 and 48 hours of admission, respectively. The Norwegian multidisciplinary guidelines (2018) concur with this view and recommend surgery preferably within 24 hours, or at least within 48 hours after admission.<sup>7</sup> The National Hip Fracture Database (NHFD) in the UK reports “prompt surgery”, defined as surgery on the day of or after admission, as a key performance indicator (KPI) in order to standardize and improve patient care.<sup>8</sup>

This study aimed to describe the temporal distribution of preoperative waiting time for surgery in patients with a hip fracture in Norway, particularly the proportion of patients receiving treatment within and outside regular working hours (08:00 to 16:00), receiving treatment within recommended waiting time, and having prompt (expedited) surgery. Further, we analyzed patient- and system-related factors affecting waiting time, and assessed potential effects on mortality of extended waiting time for surgery.

## Methods

This is a national (5.3 million inhabitants in 2018) retrospective analysis of prospective data, based on linked

data from the Norwegian Hip Fracture Register (NHFR) and the Norwegian Patient Registry (NPR). Patients’ unique national identification number enables precise coupling of data from these two registries.

**National Hip Fracture Register.** The NHFR has collected data on all hip fracture patients operated in Norwegian hospitals since 2005.<sup>9</sup> Total hip arthroplasty (THA) as primary treatment is recorded in the Norwegian Arthroplasty Register and subsequently imported to the NHFR. Data from the NHFR were used to identify patients, and for retrieval of basic information on sex, age, American Society of Anesthesiologists (ASA) class, hospital identification, fracture type, type of operation, and grouping on surgeon experience (i.e. more than three years’ experience of fracture surgery). Completeness of reporting to the NHFR is evaluated regularly, and was 88.2% for osteosynthesis, 94.5% for hemiarthroplasties, and 87.8% for THAs from 2015 to 2016.<sup>10</sup> Date of death was retrieved from the National Population Register.

**Characterization of hospitals.** All 43 hospitals treating hip fractures in Norway were included. Hospital characteristics and organization of hip fracture care (separate ward, dedicated hip fracture unit, hip fracture programme or orthogeriatric service) were obtained from a national survey of hospitals as part of this research programme.<sup>11</sup> The hospitals were grouped in quartiles by hip fracture surgery volume in the inclusion period.

**Table I.** Baseline patient characteristics.

Variable	Data
Study population, n	37,708
<b>Sex, n (%)</b>	
Females	25,586 (67.9)
Males	12,122 (32.1)
<b>Median age, yrs (IQR)</b>	83 (76 to 90)
Females	84 (78 to 91)
Males	80 (72 to 89)
<b>ASA class, n (%)</b>	
1	1,304 (3.5)
2	12,483 (33.1)
3	21,074 (55.9)
4 and 5	2,847 (7.5)
<b>Charlson Comorbidity Index, n (%)</b>	
0	26,027 (69.0)
1 to 2	8,309 (22.0)
3 to 4	2,160 (5.7)
5	1,212 (3.2)
<b>Fracture type, n (%)</b>	
Undisplaced femoral neck fracture - garden 1 to 2	4,877 (12.9)
Displaced femoral neck fracture - garden 3 to 4	17,293 (45.9)
Basocervical	1,070 (2.8)
Trochanteric AO/OTA A1	5,664 (15.0)
Trochanteric AO/OTA A2	5,919 (15.7)
Intertrochanteric AO/OTA A3	905 (2.4)
Subtrochanteric	1,980 (5.4)
<b>Treatment type, n (%)</b>	
Two or three parallel screws	5,367 (14.2)
Arthroplasty	16,725 (44.4)
Sliding hip screw	8,471 (22.5)
Intramedullary nailing	6,656 (17.7)
Other	489 (1.3)

AO, Arbeitsgemeinschaft für osteosynthesefragen; ASA, American Society of Anaesthesiologists; IQR, interquartile range; OTA, Orthopaedic Trauma Association.

**Administrative data.** Administrative data from all hospitals and other specialist healthcare providers are reported to the NPR monthly including dates and exact times for admission, discharge and surgical interventions. Furthermore, data on all in- and outpatient contacts, including ICD-10 diagnoses,<sup>12</sup> from 1 January 2013 to 31 December 2019 were obtained.

Comorbidity using the Charlson Comorbidity Index (CCI) was calculated from NPR data.<sup>13</sup> The CCI has been validated for use in Norway.<sup>14</sup>

Waiting time in hours from admission to start of surgery was calculated. In addition, we categorized waiting time according to the UK NHFD definition, i.e., surgery on the day of or after admission, in this paper expressed as expedited surgery. The number of days waiting for surgery was calculated as the difference between the dates of surgery and admission and is given as day 0 (admission day), 1 or 2, and from day three onwards as day 3+. Time of surgery was further categorized as daytime surgery (within regular working hours),

**Table II.** Hospital and structural characteristics for 37,708 hip fracture patients.

Variable	n = 37,708, n (%)
<b>Surgeons' experience in fracture surgery</b>	
< 3 years	5,145 (13.6)
> 3 years	29,584 (78.5)
Missing	2,979 (7.9)
<b>Hospital volume groups</b>	
Quartile 4 (range 1,128 to 2,639)*	18,006 (47.8)
Quartile 3 (range 746 to 1,124)*	10,074 (26.7)
Quartile 2 (range 524 to 740)*	6,913 (18.3)
Quartile 1 (range 83 to 367)*	2,715 (7.2)
<b>Hospital characteristics</b>	
<b>Orthogeriatric service</b>	
Yes	16,632 (44.1)
No	21,077 (55.9)
<b>Hip fracture programme</b>	
Yes	34,978 (92.8)
No	2,730 (7.2)
<b>Dedicated hip fracture unit</b>	
Yes	15,296 (40.6)
No	22,412 (59.4)
<b>Separate orthopaedic ward</b>	
Yes	33,048 (87.6)
No	4,660 (12.4)

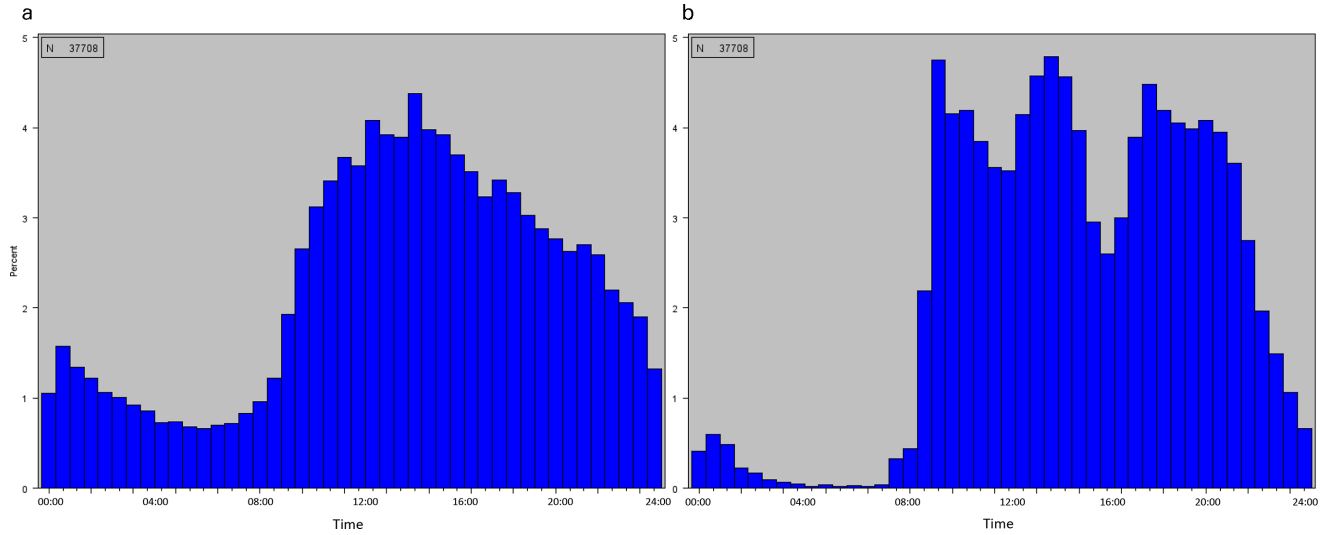
\*Range in hospital volume groups is total volume 2014 to 2018 for hospitals in quartile.

AO, Arbeitsgemeinschaft für osteosynthesefragen; OTA, Orthopaedic Trauma Association.

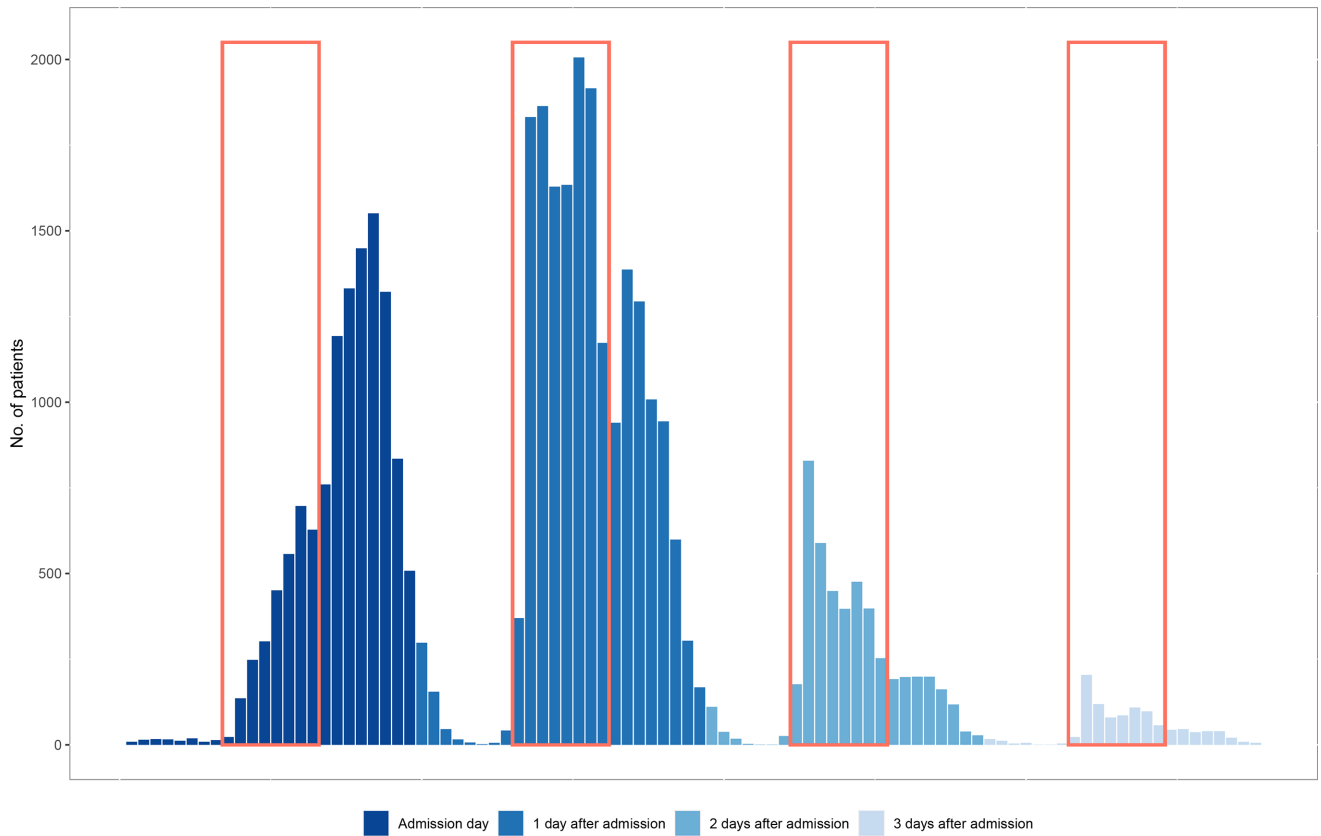
afternoon/evening surgery (after regular working hours with reduced surgical capacity; 16:00 to 24:00), and night surgery (normally reserved for emergency surgery only; 00:00 to 08:00).

To explore the effect of delaying surgery from the afternoon and night the day after admission (day 1) to daytime on the following day (day 2), we defined two patient groups: one group operated between 16:00 (day 1) and to 08:00 (day 2). The second group was operated on the following day (day 2) in daytime (08:00 to 16:00).

By 31 December 2019, the NHFR had compiled data on 41,699 fractures, admitted from 1 January 2014 to 31 December 2018 (Figure 1). Patients with missing information at time of admission or operation (n = 2,790; 6.7%), and patients with pathological fracture (n = 405; 1.0%), missing information on ASA class (n = 435; 1.0%), and combined fracture types or missing information on fracture type (n = 361; 0.9%) were excluded, leaving 37,708 (90.4%) fractures for analyses (Figure 1), made up of 25,586 females (67.9%) and 12,122 males (32.1%), with a median age of 83 years (interquartile range (IQR) 76 to 90). In analysis of mortality, patients suffering from a contralateral hip fracture within the observation time (minimum one year) were excluded (n = 938/37,708). Baseline patient characteristics are given in Table I and hospital and system characteristics are presented in Table II.



**Fig. 2**  
Time of admission a) and time of surgery and b) for 37,708 patients.



**Fig. 3**  
Temporal distribution of time of surgery after admission. Red boxes give normal working hours (08:00 to 16:00).

**Statistical analysis.** The analyses were performed using SAS/STAT for Windows v. 8.2 (SAS Institute, USA). Continuous variables are presented as medians and IQRs. Categorical variables are presented as absolute numbers and percentages. Differences between categorical variables were analyzed using multiple logistic regression,

adjusted for sex, age, and ASA class, unless stated otherwise. Age-dependent risk of death at 30 days and 365 days after surgery was estimated by logistic regression analysis. Comparison between groups and differences in means of waiting time before surgery was evaluated by analysis of variance (ANOVA) with Bonferroni corrections,

**Table III.** Patient-related factors influencing daytime and expedited surgery.

Variable	n	Daytime/working hours, n (%)	Logistic regression, OR (95% CI)	p-value*	Expedited surgery, n (%)	Logistic regression, OR (95% CI)	p-value*
<b>ASA class</b>							
1	1,304	614 (47.1)	Ref	Ref	1,169 (89.7)	Ref	Ref
2	12,483	6,447 (51.6)	1.27 (1.13 to 1.43)	< 0.001	10,946 (87.7)	0.71 (0.59 to 0.86)	= 0.001
3	21,074	11,142 (52.9)	1.37 (1.21 to 1.54)	< 0.001	17,485 (83.0)	0.47 (0.39 to 0.57)	< 0.001
4 and 5	2,847	1,607 (56.4)	1.59 (1.38 to 1.83)	< 0.001	2,143 (75.3)	0.29 (0.24 to 0.36)	< 0.001
<b>Charlson Comorbidity Index</b>							
0	26,027	13,554 (52.1)	Ref	Ref	22,152 (85.1%)	Ref	Ref
1 to 2	8,309	4,456 (53.6)	1.07 (1.01 to 1.12)	= 0.013	6,885 (82.9)	0.85 (0.80 to 0.91)	< 0.001
3 to 4	2,160	1,152 (53.3)	1.05 (0.96 to 1.15)	= 0.246	1,733 (80.2)	0.73 (0.65 to 0.81)	< 0.001
5	1,212	648 (53.5)	1.06 (0.94 to 1.19)	= 0.357	973 (80.3)	0.73 (0.63 to 0.84)	< 0.001
<b>Fracture type</b>							
Displaced FNF - garden 3 to 4	17,293	10,036 (58.0)	Ref	Ref	14,175 (82.0)	Ref	Ref
Undisplaced FNF - garden 1 to 2	4,877	2,176 (44.6)	0.58 (0.55 to 0.62)	< 0.001	4,148 (85.0)	1.21 (1.11 to 1.32)	< 0.001
Basocervical	1,070	527 (49.3)	0.70 (0.62 to 0.79)	< 0.001	929 (86.8)	1.49 (1.24 to 1.78)	< 0.001
Trochanteric AO/OTA A1	5,664	2,686 (47.4)	0.65 (0.62 to 0.69)	< 0.001	4,851 (85.7)	1.32 (1.21 to 1.43)	< 0.001
Trochanteric AO/OTA A2	5,919	2,909 (49.2)	0.70 (0.66 to 0.74)	< 0.001	5,098 (86.1)	1.37 (1.26 to 1.49)	< 0.001
Intertrochanteric AO/OTA A3	905	437 (48.3)	0.67 (0.59 to 0.77)	< 0.001	780 (86.2)	1.39 (1.15 to 1.69)	< 0.001
Subtrochanteric	1,980	1,039 (52.5)	0.80 (0.72 to 0.88)	< 0.001	1,762 (90.0)	1.78 (1.54 to 2.07)	< 0.001
<b>Treatment type</b>							
Arthroplasty	16,725	9,757 (58.3)	Ref	Ref	13,629 (81.5)	Ref	Ref
2 or 3 parallel screws	5,367	2,418 (45.1)	0.58 (0.54 to 0.61)	< 0.001	4,631 (86.3)	1.41 (1.29 to 1.55)	< 0.001
Sliding hip screw	8,471	3,970 (46.9)	0.63 (0.60 to 0.66)	< 0.001	7,247 (85.6)	1.35 (1.26 to 1.46)	< 0.001
Intramedullary nailing	6,656	3,427 (51.5)	0.76 (0.72 to 0.80)	< 0.001	5,809 (87.3)	1.57 (1.44 to 1.70)	< 0.001
Other	489	238 (48.7)	0.67 (0.56 to 0.80)	< 0.001	427 (87.3)	1.60 (1.22 to 2.10)	< 0.001

\*Logistic regression analyses adjusted for sex, age and ASA class, except analyses on American Society of Anesthesiologists and Charlson Comorbidity Index where American Society of Anesthesiologists class is excluded. ASA, American Society of Anesthesiologists; CI, confidence interval; FNF, femoral neck fracture; OR, odds ratio; OTA, Orthopaedic Trauma Association.

**Table IV.** Hospital- and system-related factors influencing daytime and expedited surgery.

Variable	n	Daytime/working hours, n (%)	Logistic regression, OR (95% CI)	p-value*	Expedited surgery	Logistic regression, OR (95% CI)	p-value*
<b>Surgeon's experience in fracture surgery</b>							
> 3 years	29,584	15,565 (52.6)	Ref	Ref	24,967 (84.4)	Ref	Ref
< 3 years	5,145	2,240 (43.5)	0.70 (0.66 to 0.74)	< 0.001	4,447 (86.4)	1.11 (1.04 to 1.19)	= 0.003
Missing	2,979	N/A	N/A	N/A	N/A	N/A	N/A
<b>Hospital volume groups</b>							
High volume (quartile 4)	18,006	9,712 (53.9)	Ref	Ref	14,570 (80.9%)	Ref	Ref
Intermediate-high volume (quartile 3)	10,074	4,925 (48.9%)	0.81 (0.78 to 0.86)	< 0.001	8,591 (85.3%)	1.39 (1.30 to 1.49)	< 0.001
Intermediate-low volume (quartile 2)	6,913	3,555 (51.4)	0.90 (0.85 to 0.95)	< 0.001	6,180 (89.4)	2.05 (1.88 to 2.23)	< 0.001
Low volume (quartile 1)	2,715	1,618 (59.6)	1.26 (1.16 to 1.37)	< 0.001	2,402 (88.5)	1.83 (1.62 to 2.07)	< 0.001
<b>Orthogeriatric service</b>							
Yes	16,631	8,820 (53.0)	Ref	Ref	13,940 (83.3)	Ref	Ref
No	21,077	10,990 (52.1)	0.97 (0.93 to 1.01)	= 0.110	17,803 (84.5)	1.04 (0.96 to 1.10)	= 0.157
<b>Hip fracture programme</b>							
Yes	34,978	18,320 (52.4)	Ref	Ref	29,273 (83.7)	Ref	Ref
No	2,730	1,490 (54.6)	1.10 (1.02 to 1.19)	= 0.020	2,470 (90.5)	1.84 (1.62 to 2.10)	< 0.001
<b>Dedicated hip fracture unit</b>							
Yes	15,296	8,441 (55.2)	Ref	Ref	12,562 (82.1)	Ref	Ref
No	22,412	11,369 (50.7)	0.84 (0.80 to 0.87)	< 0.001	19,181 (85.6)	1.30 (1.23 to 1.38)	< 0.001
<b>Separate orthopaedic ward</b>							
Yes	33,048	17,355 (52.5)	Ref	Ref	27,549 (83.4%)	Ref	Ref
No	4,660	2,455 (52.7)	1.01 (0.95 to 1.08)	= 0.721	4,194 (90)	1.78 (1.61 to 1.96)	< 0.001

\*Logistic regression analyses were adjusted for sex, age, and American Society of Anesthesiologists class. ASA, American Society of Anesthesiologists; CI, confidence interval; N/A, not applicable; OR, odds ratio.

and the corrections were justified due to the non-normal distribution of the observations. Association between volume and proportion treated expedited was evaluated by a linear regression model. Significance was set at 5% in all analyses.

**Ethics, funding, and conflict of interest.** The project was approved by the Northern Norway Regional Committee for Medical and Health Research Ethics and was exempted from the duty of confidentiality (REK 2018/1955). A data protection integrity assessment was compiled according

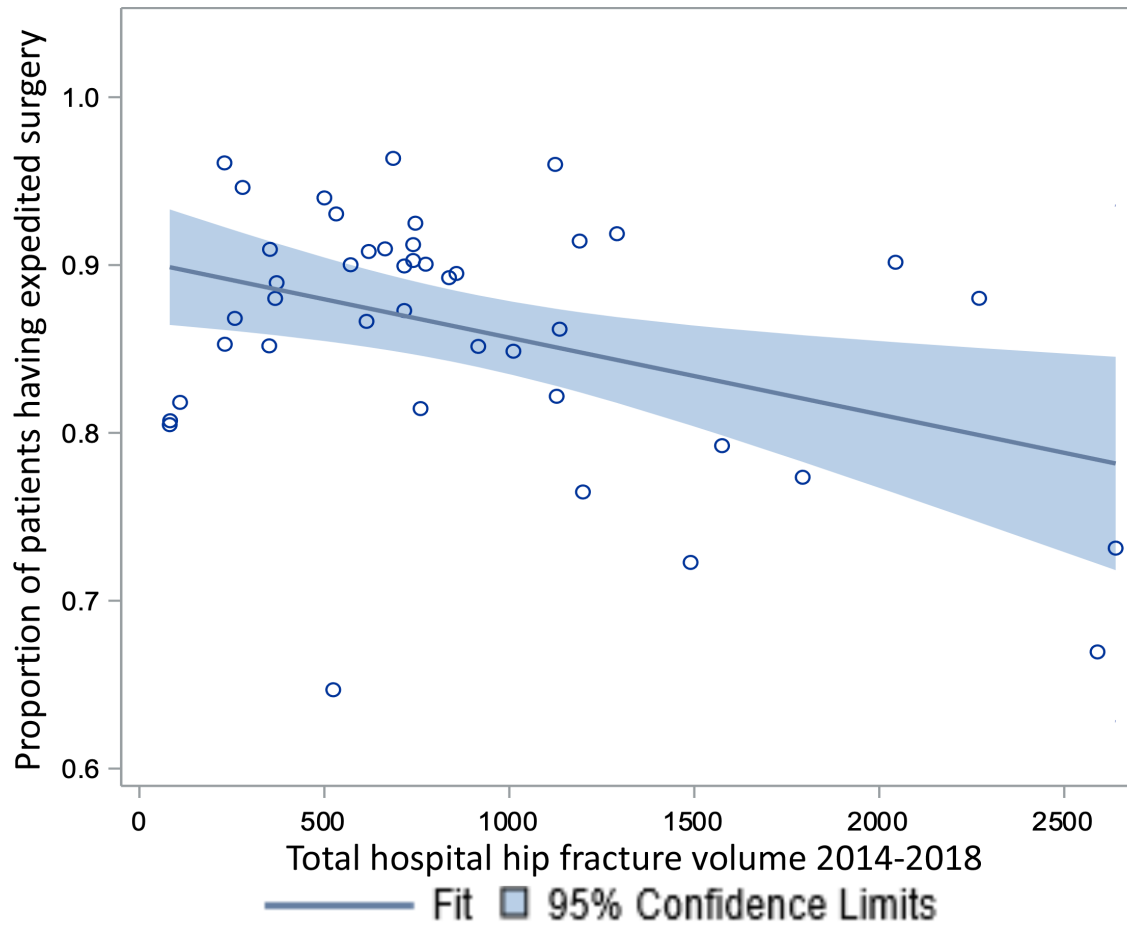


Fig. 4

Scatter plot and linear regression displaying proportion of patients having expedited surgery related to hip fracture volume.

to the EU General Data Protection Regulation (GDPR). The project was funded by the Northern Norway Regional Health Authority (HNF1482-19). The NHFR is financed by the Western Norway Regional Health Authority. No competing interests were declared.

## Results

**Time of admission and time of surgery.** Admission time to hospital is illustrated in Figure 2a. Overall, 17,326 patients (46.0%) were admitted during daytime, 15,123 (40.1%) in the afternoon or evening, and 5,259 (14.0%) at night. Time for start of surgery on the day of operation, irrespective of waiting time, is shown in Figure 2b. In all, 19,810 patients (52.5%) were operated during daytime, while 16,972 (45.0%) were operated on in the afternoon or evening. Night-time surgery was rarely performed ( $n = 926$ ; 2.5%).

**Distribution of time of surgery related to waiting time.** The temporal distribution of time of surgery after admission is illustrated in Figure 3. A total of 12,103 of patients (32.1%) were operated on the day of admission (day 0), 19,640 (52.1%) the day after admission (day 1), 4,901 (13.0%) on day 2, and 1,064 (2.8%) on day 3 or

later (day 3+). An increasing proportion were operated during daytime and regular working hours for every day that passed: 3,042 (25%) on day 0, 12,424 (63%) on day 1, and 3,568 (73%) on day 2 and day 3+. Overall, 288 patients (27%) operated on day 3+ had afternoon/evening or night surgery, and 243 surgeries (4%) took place at night-time from day 2 and onwards.

**Patient-related factors and timing of surgery.** High-risk patients (i.e. higher ASA class) were more often treated during daytime (Table III). Displaced femoral neck fractures (FNFs) were more likely to be treated during daytime and within regular working hours than all other fracture types. Arthroplasties were also more frequently performed in daytime than other procedures (Table III).

Both higher ASA class and CCI score reduced the likelihood of receiving expedited treatment (Table III). Subtrochanteric fractures were more likely to receive expedited surgery. Arthroplasties were less likely to receive expedited surgery than all other surgical procedures.

**Hospital/system factors and timing of surgery.** Less experienced surgeons operated fewer patients in daytime and within regular working hours, but a higher proportion within the period defined as expedited surgery

**Table V.** Differences in mean waiting time for surgery for specific groups analyzed with analysis of variance statistics.

Variable	n (%)	Mean	95% CI	p-values < 0.05 marked by *
Mean total waiting time	37,708	22 h 36 m		
<b>ASA class</b>				
1	1,304	Ref	Ref	
2	12,483	3 h 21 m	1 h 40 m to 5 h 2 m	*
3	21,074	6 h 22 m	4 h 43 m to 8 h 0 m	*
4/5	2,847	12 h 5 m	10 h 16 m to 13 h 53 m	*
<b>Charlson Comorbidity Index</b>				
0	26,027	Ref	Ref	
Ref1 to 2	8,309	1 h 20 m	38 m to 2 h 1 m	*
3 to 4	2,160	3 h 35 m	2 h 22 m to 4 h 48 m	*
5-	1,212	4 h 3 7 m	3 h 1 m to 6 h 13 m	*
<b>Fracture type</b>				
Displaced FNF - garden 3 to 4	17,293	Ref	Ref	
Undisplaced FNF - garden 1 to 2	4,877	- 1 h 56 m	-2 h 57 m to - 55 m	*
Basocervical	1,070	- 1 h 40 m	-3 h 38 m to 19 m	
Trochanteric AO/OTA A1	5,664	- 2 h 21 m	- 3 h 19 m to - 1 h 24 m	*
Trochanteric AO/OTA A2	5,919	- 2 h 49 m	- 3 h 46 m to - 1 h 53 m	*
Intertrochanteric AO/OTA A3	905	- 2 h 34 min	- 4 h 43 m to - 27 m	*
Subtrochanteric	1,980	- 4 h 22 m	- 5 h 52 m to - 2 h 53 m	*
<b>Treatment type</b>				
Arthroplasty	16,725	Ref	Ref	
2/3 parallel screws	5,367	- 2 h 54 m	- 3 h 48 m to - 1 h 59 m	*
Sliding hip screw	8,471	- 2 h 22 m	- 3 h 8 m to - 1 h 35 m	*
Intramedullary nailing	6,656	- 3 h 49 m	- 4 h 39 m to - 2 h 59 m	*
Other	489	- 3 h 51 m	- 6 h 31 m to - 1 h 12 m	*
<b>Hospital volume groups - increasing volume</b>				
Quartile 4	18,006	Ref	Ref	
Quartile 3	10,074	10 m	- 1 h 4 m to 1 h 24 m	
Quartile 2	6,913	- 3 h 31 m	- 4 h 42 m to - 2 h 21 m	*
Quartile 1	2,715	- 4 h 54 m	- 6 h 1 m to - 3 h 47 m	*

The minus sign indicates a shorter waiting time than the reference value. In ANOVA analyses, the test show if variance is of such degree that the p-value is below a pre-set value  $< 0.05$ .

AO, Arbeitsgemeinschaft für osteosynthesefragen; CI, confidence interval; FNF, femoral neck fracture; IQR, interquartile range; OTA, Orthopaedic Trauma Association.; SD, standard deviation.

(Table IV). There was a significant trend that high volume hospitals had a lower proportion of patients treated with expedite surgery than low volume hospitals ( $r^2 = 0.1528$ ;  $df = 41$ ; mean square error 0.0048) (Figure 4).

An orthogeriatric service unit did not increase the proportion of patients having surgery within regular working hours or as expedited surgery. A dedicated hip fracture unit increased the proportion of patients having a daytime operation, but reduced the proportion having expedited surgery. A separate orthopaedic ward reduced the proportion of patients having expedited surgery (Table IV).

**Differences in mean waiting time.** Waiting time increased significantly with higher ASA classes and increasing CCI (Table V). Displaced FNFs treated with arthroplasty had statistically significantly longer waiting times than all other fractures and treatment types, except basocervical fractures (Table V). High-volume (Q4) hospitals had significantly longer waiting times than

low volume (Q1) and intermediate low-volume (Q2) hospitals. Low-volume (Q1) hospitals had almost five hours shorter waiting time (Table V).

**Consequences of the timing of surgery.** In unadjusted logistic regression analyses, non-expedited surgery resulted in higher 30-day and one-year mortality rates compared to expedited surgery (OR 1.19; 95% confidence interval (CI) 1.08 to 1.31;  $p < 0.001$ , and OR 1.13; 95% CI 1.06 to 1.20;  $p < 0.001$ , respectively). Working hours surgery on day 2 increased 30-day and one-year mortality compared to afternoon/evening/night surgery on day 1 in unadjusted analyses (Table VI). Adjusting for age, sex, and ASA class resulted in insignificant effects on mortality, whereas analyses adjusted for age, sex and CCI demonstrated that not receiving expedited surgery resulted in higher mortality rates. Figure 5 illustrates the effect on 30-day mortality for each ASA class and CCI group related to age. There was a statistically significant higher 30-day mortality rate for

**Table VI.** The effect of expedite surgery and a subgroup analysis comparing surgery in the afternoon/night of day one with daytime surgery day two 30-day and one-year mortality.

Effect	Unadjusted,		Age/sex, OR		Age/sex/ASA,		Age/sex/CCI,	
	OR (95% CI)	p-value*	(95% CI)	p-value*	OR (95% CI)	p-value*	OR (95% CI)	p-value*
Afternoon/night day 1 vs daytime day 2								
<b>30-day mortality</b>								
<b>Expedite surgery</b>								
Yes	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
No	1.19 (1.08 to 1.31)	< 0.001	1.19 (1.08 to 1.32)	= 0.001	0.99 (0.89 to 1.10)	= 0.841	1.16 (1.05 to 1.29)	= 0.004
<b>Afternoon/night day 1 vs daytime day 2</b>								
Day 1	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Day 2	1.22 (1.05 to 1.41)	= 0.008	1.26 (1.08 to 1.46)	= 0.003	1.08 (0.93 to 1.27)	= 0.306	1.22 (1.05 to 1.42)	= 0.010
<b>One-year mortality</b>								
<b>Expedite surgery</b>								
Yes	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
No	1.13 (1.06 to 1.20)	< 0.001	1.14 (1.06 to 1.22)	< 0.001	0.96 (0.89 to 1.03)	= 0.243	1.10 (1.02 to 1.17)	= 0.011
Day 1	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Day 2	1.10 (1.00 to 1.21)	= 0.047	1.14 (1.03 to 1.26)	= 0.010	1.01 (0.91 to 1.12)	= 0.857	1.10 (1.00 to 1.22)	= 0.057

\*All analyses are logistic regressions. Adjustments stated in column heading.

ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index; CI, confidence interval; OR, odds ratio.

non-expedited surgery than for expedited surgery in all CCI groups (OR 1.16; 95% CI 1.05 to 1.29;  $p = 0.004$ ). All analyses were carried out by logistic regression, with adjustment stated in each analyses.

## Discussion

The waiting time issue has been addressed using three indicators; waiting time in hours, surgery within regular working hours, and the UK KPI indicator expedited surgery (prompt surgery). Patient comorbidity, expressed as both higher ASA class and CCI score, increased waiting time. Similarly, fracture type and surgical procedure affected waiting time. Displaced FNF and treatment with arthroplasty prolonged waiting time, but at the same time increased the probability of surgery within regular working hours. We hypothesize that specialized surgeons performed the arthroplasties, especially THAs, in working hours. Other treatment alternatives may be considered less technically demanding, and require less surgical experience.

Compared to arthroplasties, other fracture treatments more frequently were performed outside regular working hours, and were more often performed by less experienced surgeons.

The high-volume (Q4) hospital group had significantly longer waiting times and a lower proportion of

patients treated during regular working hours than Q1 to Q3 volume groups. The larger hospitals should have resources and staff to perform surgery for a longer period of the day. Recently Nilsen et al<sup>15</sup> demonstrated that strained hospital resources, increased waiting time to surgery by 20% and led to a 20% higher 60-day mortality. This supports our contention that hip fracture patients are not prioritized in hospital management.

Waiting time is a modifiable risk factor. Reimbursement schemes introduced to encourage expedited surgery have been followed by reduced preoperative waiting time.<sup>16</sup> Introduction of the Best Practice Tariff (BPT) in the UK reduced preoperative waiting time and one-year mortality rate.<sup>17</sup> Some hospitals have restructured fracture care for elderly people but with inconclusive effects.<sup>18–20</sup> The paradoxical effect on waiting time by system factors changes as demonstrated here, is a finding we cannot explain. Currently, there is no professional consensus nor high-level scientific evidence for the effectiveness of system changes. Despite the inconclusive scientific literature, optimization of patient pathways with a focus on reducing unnecessary waiting should have high priority in day-to-day management.

Comorbidity was a factor in delayed surgery, but was also an independent predictor of postoperative mortality. Our interpretation is that the increased mortality we



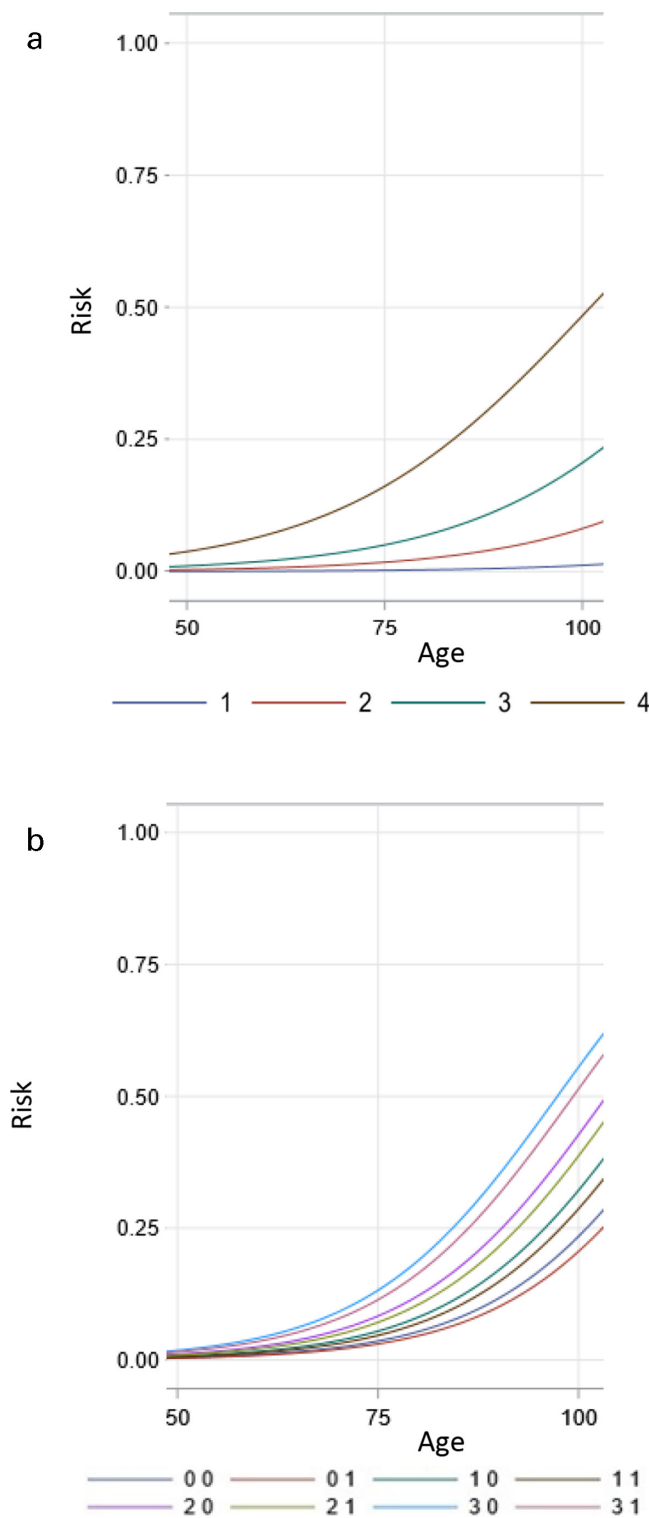


Fig. 5

Mortality at 30 days postoperatively related to age of patients.

observed when waiting time was prolonged was explained by a delay in surgery for patients with greater comorbidity. Consequently, there is a balance between preoperative optimization of the patient and increasing

waiting time.<sup>21</sup> Waiting an extra night was associated with increased mortality in the postoperative period. An extra night may improve the fitness of patients with significant comorbidities but at the potential expense of a higher mortality, and increases patient's discomfort by waiting immobilized.

In a narrative literature review, Lewis et al<sup>21</sup> documented that ASA class was a consistent predictor of 30-day mortality, while CCI expresses more underlying chronic diseases and pre-fracture function which also affects mortality. However, others have shown a low predictive power of comorbidity indices for mortality after hip fractures treated with arthroplasty.<sup>22</sup> Recently, Narula et al<sup>23</sup> has shown, in a retrospective study, that the Clinical Frailty Scale (CFS) was a good predictor of mortality for hip fracture patients. CFS can not be estimated based on routine administrative data but CFS data should be recorded in future prospective studies.

The increased postoperative death rate associated to treatment delay both in medically fit and unfit patients<sup>21</sup> are not substantial but in line with findings in other studies.<sup>2,3,24</sup> A support for the notion that delay is associated with increased mortality is the subgroup analysis comparing day 1/afternoon and evening surgery and surgery day two/working hours operations. Although the negative effect of treatment delay on mortality is relatively small, a more focused professional attention on delay as a health issue problem, could rectify this problem.

Both from a patient and health policy perspective, variations in waiting time for surgery is unwarranted healthcare inequality. Any contrast in hospital waiting time must be considered unwarranted. We conclude that expedited surgery, as used in the UK, is a better indicator than hours of waiting, embracing both the aspects of time and patient discomfort.

**Strengths and limitations.** The main strengths of the study are the large study population and the inclusion of all hospitals in Norway routinely treating hip fractures. We were not able to prove causality, although an association between mortality (or survival) and treatment delay has been documented. We acknowledge that pre-hospital waiting time was not included in our analysis. A previous study from the NHFR has shown that the median time from fracture to admission is six hours.<sup>3</sup> Given a mean in-hospital waiting time of 23 hours in this study, we find it unlikely that the addition of pre-hospital waiting time would have led to different results and changed our conclusions.

The findings in this study clearly indicate inequity in waiting time for hip fracture treatment in Norway. Variations in waiting time from admission to hip fracture surgery depended on both patient and hospital factors. Not receiving expedited treatment was associated with increased 30-day and one-year mortality rates. Further studies should address why such differences occur and

whether specific patient groups should be prioritized differently.



### Take home message

- There is a substantial variation in waiting time for surgery after admission.
- Both patient and hospital factors affect waiting time.
- Prolonged waiting time for surgery increases 30-day and one-year mortality.

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- J-E. Gjertsen: Analyzed and interpreted the data, Edited and revised the manuscript.
- L. B. Engeseter: Analyzed and interpreted the data, Drafted, edited, and revised the manuscript.
- E. Stensland: Oversaw the research programme and protocol, Designed the study, Edited and revised the manuscript.
- E. Dybvik: Acquired, analyzed, and interpreted the data, Edited and revised the manuscript.
- O. Soreide: Oversaw the research programme and protocol, Designed the study, Analyzed and interpreted the data, Drafted, edited, and revised the manuscript.

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- The project was approved by the Northern Norway Regional Committee for Medical and Health Research Ethics and was exempted from the duty of confidentiality (REK

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