



Original Article

An evaluation of the outcome metric 'days alive and at home' in older patients after hip fracture surgery

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Summary

'Days alive and at home' is a validated measure that estimates the time spent at home, defined as the place of residence before admission to hospital. We evaluated this metric in older adults after hip fracture surgery and assessed two follow-up durations, 30 and 90 days. Patients aged ≥ 70 years who underwent hip fracture surgery were identified retrospectively via hospital admission and government mortality records. Patients who successfully returned home and were still alive within 90 days of surgery were distinguished from those who were not. Regression models were used to examine which variables were associated with failure to return home and number of days at home among those who did return, within 90 days of surgery. We analysed the records of 825 patients. Median (IQR [range]) number of days at home within 90 days ($n = 788$) was 54 (0–76 [0–88]) days and within 30 days ($n = 797$) it was 2 (0–21 [0–28]) days. Out of these, 274 (35%) patients did not return home within 90 days and 374 (47%) within 30 days after surgery. Known peri-operative risk-factors such as older age, pre-operative anaemia and postoperative acute renal impairment were associated with failure to return home. This study supports days alive and at home as a useful patient-centred outcome measure in older adults after hip fracture surgery. We recommend that this metric should be used in clinical trials and measured at 90, rather than 30, postoperative days. As nearly half of this patient population did not return home within 30 days, the shorter time-period catches fewer meaningful events.

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Introduction

Recent decades have seen an increasing emphasis on quality assurance in anaesthesia, including not only safety but also patient experience [1–4]. Surgical outcomes are

traditionally indicated by mortality or length of hospital stays. However, these endpoints only partially capture a patient's postoperative recovery journey and quality of survival [2, 3, 5].

‘Days alive and at home’ has three contributing elements: initial acute and subacute hospital stays; duration of any hospital re-admissions and/or new care facility admissions; and mortality. By combining these outcome measures, days alive and at home reflects both quality of life and daily function [3, 6–10]. In older adults, zero days at home can reflect death, prolonged hospitalisation or a permanent move to higher levels of care. Thus, days alive and at home represents a pragmatic, patient-centred outcome measure that approximates the time spent in ‘good’ health [11–13]. Days alive and at home includes multiple postoperative key events and weights early death more than hospitalisation. Unlike many complication-based outcomes in peri-operative research, more days at home are better than fewer days at home.

Days alive and at home has been validated in several surgical populations [11–16] and is used to evaluate outcomes for specific patient factors and surgical procedures. However, there is debate as to the relative value of days alive at home within 30 days of surgery vs. 90 days of surgery; the latter is more complex to collect and may not add important new information for many surgical populations [12–14]. There is currently little research on days alive and at home after hip fracture surgery, one of the most common emergency operations for older adults [17]. This is a high-risk patient group which is likely to have extended hospital stays, multiple complications, frequent re-admissions and high mortality rates [18–20]. We aimed to investigate the utility of days alive and at home within 90 days of surgery as a research metric for patients undergoing surgical repair of hip fracture.

Methods

We conducted a historical cohort study in an Australian metropolitan healthcare network, which comprises two major acute hospitals and two subacute hospitals. The study was approved by the local institution’s human research ethics committee.

Patients aged ≥ 70 y were included if they were admitted to our primary site for operative management of a hip fracture between July 2011 and July 2015. Patients were not studied if they were managed non-operatively, re-admitted for a second hip fracture within 90 days of their first operation or had incomplete data (this included those who were transferred to an external network and those whose operations were not performed at the primary site within our healthcare network). In cases where included patients had multiple admissions for hip fracture operations, only their first procedure was included.

Patients were identified via the hospital diagnostic-related group database and verified with their electronic medical records through InfoMedix Clinical Patient Folder (InfoMedix Pty Ltd, Melbourne, Australia). Baseline characteristics and peri-operative variables were recorded from this database. Mortality data were obtained from, and correlated against, government records (Victorian Registry of Births, Death and Marriages) as well as their individual electronic medical record for a further year after surgery.

Peri-operative variables (see also online Supporting Information, Appendix S1) included: ASA physical status scores; duration of stay for all admissions and re-admissions within 90 days of surgery; pre-operative residential settings; discharge destinations; presence of pre-operative dementia, anaemia or chronic kidney disease; development of postoperative acute renal impairment; peri-operative blood transfusions or ICU admissions; and timing of surgery (including time of day and whether within 48 h of hospital admission).

We defined ‘home’ as the place where the patient usually resided before their index admission, which could be their own home (privately owned or government housing), living with family or a nursing home.

The primary outcome was the number of days alive and at home at 90 days after surgery (DAH₉₀). This was calculated by adding the duration of stay in hospital (during both the index admission and any subsequent re-admissions) and periods in post-acute settings (such as rehabilitation wards or a new care facility) between the date of the index operation and the 90th day thereafter, and subtracting the total from the 90-day period. DAH₉₀ was defined as zero if a patient died during the 90 days, even if they spent time in their home. This definition is consistent with other studies [11–14].

Unfortunately, the current literature lacks consensus on the terminology used for this metric. ‘Days alive and at home’ [12, 13], ‘days alive and out of hospital’ [14–16] and ‘home-to-home days’ [21] are related metrics. To avoid confusion, we proposed to standardise the use of ‘days alive and at home’ for the above metrics, and exclude the time spent in hospital or any new care facilities. Based on this definition, we distinguished patients who successfully returned to their home and were still alive within 90 days of surgery (DAH₉₀ > 0) from those who did not (DAH₉₀ = 0).

Our secondary outcome was to assess days alive and at home 30 days postoperatively (DAH₃₀) (this was calculated similarly to DAH₉₀); we also aimed to examine which explanatory variables were associated with failure to return home within 90 days, and document the number of days at

home among patients who did return to their home within 90 days.

The distribution of DAH_{90} was both zero-heavy and negatively skewed (Fig. 1a). To account for the zero-heaviness, overdispersion and skew evident in the DAH_{90} data, DAH_{90} was modelled using a zero-adjusted beta-binomial regression [22]. The zero-adjusted model was used to examine association with explanatory variables by estimating it via its component parts as a logistic regression model with failure to return home within 90 days as the outcome, and a zero-truncated beta-binomial regression model with whether a patient was in their home, on any given day, as the outcome (given they had returned to their home). In both models, the logit link function was used for mean parameters, and so estimates of association could be interpreted as OR (95% CI) and associated p values. In the second model, each patient's 90-day observation period can be regarded as 90 single-day trials, and a 'day at home' as a success. The correlation among trials observed on the

same patient was accounted for by allowing beta variation in the binomial probability parameter [23].

There was a non-linear relation between age and outcome on the logit scale in both models above. In each case, a smoothing plot indicated that the magnitude of association varied around the 85- and 90-year thresholds. Thus, age was modelled as a categorical effect using these thresholds, and with patients aged 70–85 y as the reference category.

Statistical analysis was conducted using R version 4.0.1 [24]. The `gamlss` package (version 5.1-6) was used to estimate the zero-truncated beta-binomial regression model and to make overall predictions using a jointly estimated zero-adjusted count model [25, 26].

Results

A total of 1048 older adults were admitted to our primary hospital with a hip fracture during the study period (Fig. 2). Among them, 19 patients had further admissions for

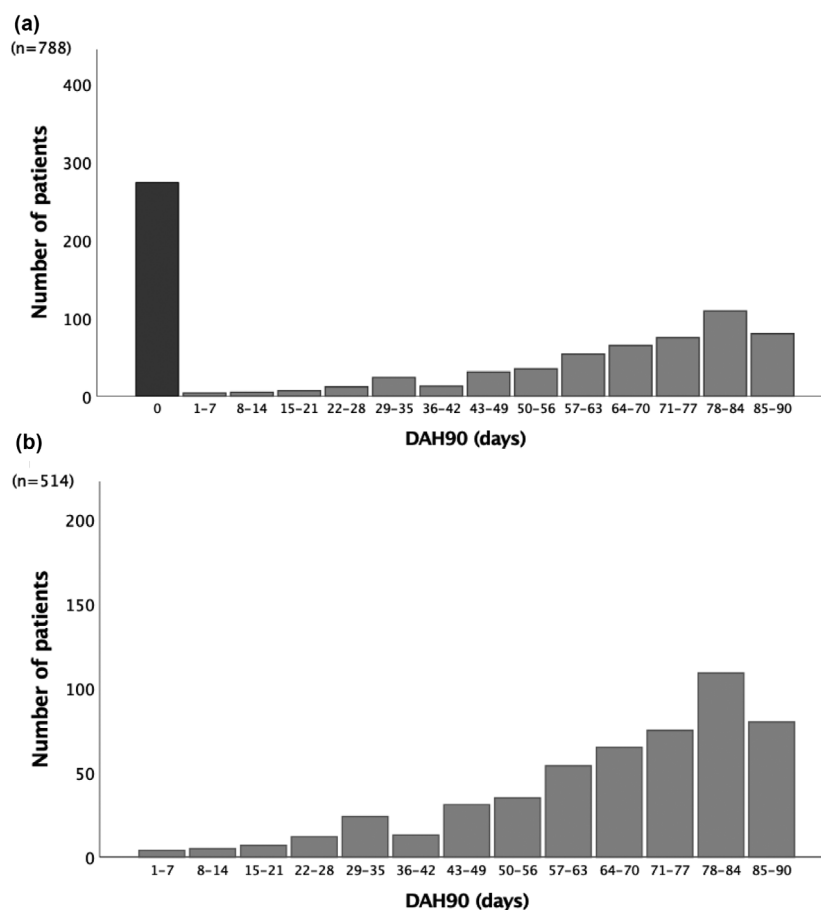


Figure 1 Distribution of DAH_{90} for (a) all patients and (b) those who successfully returned to their home within 90 postoperative days.

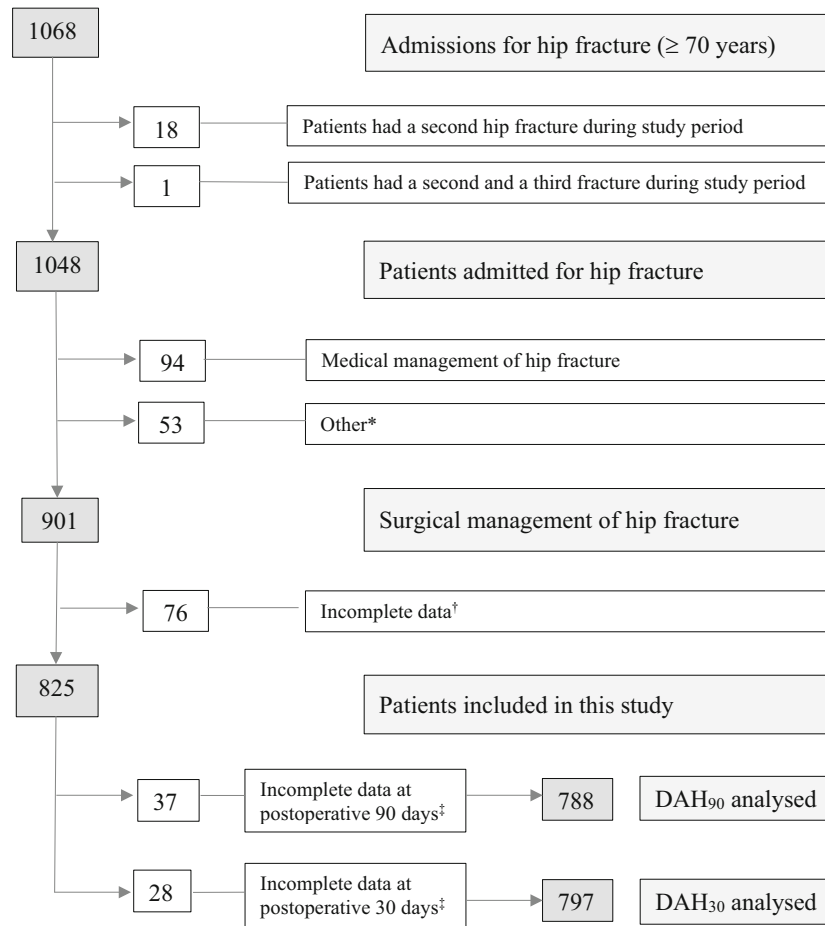


Figure 2 Patient selection based on inclusion and exclusion criteria. * Mainly due to being transferred to an external healthcare network. † Mainly due to having surgery in other hospitals, including the other acute hospital within our healthcare network, before or after the index hospital admission. ‡ Mainly due to being discharged to external healthcare network or having missing information before the 90th or the 30th postoperative day.

subsequent hip fractures (18 were admitted twice and one patient three times); only the first admission was included. There were 223 patients who were not studied, including 94 who were conservatively managed and 76 who had operations outside the primary site. Baseline characteristics and peri-operative factors for the remaining 825 patients are summarised in Table 1.

There were 37 patients (4%) who were lost to follow-up at hospital discharge before 90 days and 28 patients (3%) before 30 days. This was primarily due to being discharged to an external healthcare network or having missing information (see also online Supporting Information, Figure S1). As such, their data on days alive and at home were not available for analysis, that is, there were 788 patients remaining for DAH₉₀ and 797 for DAH₃₀ analyses.

The distribution of DAH₉₀ was dominated by the high frequency of patients with a value of zero days (Fig. 1a). Median (IQR [range]) DAH₉₀ was 54 (0-76 [0-88]) days. Out

of these patients, 274 (35%) did not return home (DAH₉₀ = 0): 147 patients died and 127 patients remained in hospital or a new care facility within 90 days. Median (IQR [range]) of acute and subacute hospital stays were 8 (6-11 [0-64]) days and 11 (0-27 [0-204]) days, respectively. Re-admission occurred for 108 patients (14%) with median (IQR [range]) re-admission duration of 7 (4-16 [1-73]) days. Out of these, 15 were re-admitted twice and one patient three times. Overall median (IQR [range]) interval between hospital discharge and re-admission was 18 (6-37 [0-82]) days.

Among 514 patients (65%) who survived and returned to their home, median (IQR [range]) DAH₉₀ was 71 (56-83 [4-88]) days. Out of these, 189 (37%) were discharged early (discharged within postoperative 2 weeks) with a majority (167, 88%) returning to their nursing home and only 22 (12%) to their own home.

Overall median (IQR [range]) DAH₃₀ was 2 (0-21 [0-28]) days; among them, 374 patients (47%) did not return home,

Table 1 Baseline characteristics and peri-operative factors. Values are mean (SD), number (proportion) or median (IQR [range]).

Variables	Values
Age, y	84.7 (6.9)
Male sex	223 (27%)
ASA physical status	
1-2	114 (14%)
3	460 (58%)
≥4	215 (27%)
Postoperative mortality	
In-hospital	58 (7%)
30-day	87 (11%)
90-day	147 (18%)
1-year	239 (29%)
Length of hospital stay in days	
Acute*	8 (6-11 [0-64])
Subacute†	11 (0-27 [0-204])
90-day postoperative re-admissions	108 (14%)
Re-admission duration in days‡	7 (4-16 [1-73])
Interval between hospital discharge and re-admission in days	18 (6-37 [0-82])
Blood transfusion	287 (35%)
Daytime surgery	566 (69%)
Pre-operative chronic kidney disease stage	
3	365 (45%)
4 or 5	64 (8%)
Pre-operative residential setting	
Nursing home§	342 (42%)
HLCNH	222 (65%)
LLCNH	120 (35%)
Own home	475 (58%)
Returned to own home for those originating from there	
At 30 postoperative days	173 (38%)
At 90 postoperative days	288 (65%)
Pre-operative dementia	297 (36%)
Pre-operative residential setting of those with dementia	
Nursing home§	239 (80%)
HLCNH	183 (77%)
LLCNH	56 (23%)
Own home	58 (20%)
Direct discharge destination¶	
Original nursing home	257 (76%)
Own home	20 (6%)
External hospital/new nursing home	32 (9%)
In-hospital death	28 (8%)

(continued)

Table 1 (continued)

Variables	Values
Final discharge destination	
Original nursing home	296 (36%)
Own home	317 (39%)
Hospitals/new or higher level nursing home	148 (18%)
In-hospital death	58 (7%)

HLCNH, high level care nursing home; LLCNH, low level care nursing home.

*Length of hospital acute stays during the initial hospitalisation and subsequent 90 postoperative day re-admissions after excluding the 37 patients with incomplete data.

†Length of hospital subacute stays during the initial hospitalisation and subsequent 90 postoperative day re-admissions after excluding the 37 patients with incomplete data.

‡Length of hospital stays during the hospital re-admissions within 90 postoperative days after excluding the 37 patients with incomplete data.

§Nursing home includes HLCNH and LLCNH.

¶Hospital discharge from the initial acute care during the index admission.

including 87 patients who died and 287 who remained in hospital or a new care facility during this period. For those who did return to their home, median (IQR [range]) DAH₃₀ was 20 (10-24 [1-28]) days.

The results for associations between baseline characteristics or peri-operative factors and failure to return home are reported in Table 2. The odds of not returning home increased about two-fold for patients aged ≥85 y, compared with younger patients. We note also that the odds of failure to return home was about one and a half times greater when pre-operative dementia was present, compared with when it was absent. Other factors associated with failure to return home were as follows: male sex; pre-operative anaemia; and postoperative acute renal impairment. There was also a tendency towards an association with increasing ASA physical status.

The results for associations between baseline characteristics or peri-operative factors and number of days at home, among patients who did return home within 90 days, are reported in Table 3. The odds of a patient having an additional day at home decreased by 21% among patients aged 85-89 y, compared with younger patients. However, this negative age effect was not apparent among older patients aged > 89 y. Moreover, the odds of a patient having an additional day at home increased about two and a half fold when pre-operative dementia was present, compared with when it was absent.

Table 2 The association between failure to return home within 90 postoperative days and baseline characteristics or peri-operative factors.

	OR* (95%CI)	p value
Age (reference < 85 y)		<0.001
85–89 y	1.91 (1.30–2.80)	-
>89 y	1.90 (1.28–2.81)	-
Male sex	1.49 (1.04–2.13)	0.03
ICU admission	1.02 (0.67–1.53)	0.94
ASA physical status (reference < 3)		0.06
3	1.61 (0.95–2.82)	-
≥4	2.04 (1.13–3.76)	-
Postoperative acute renal impairment	1.72 (1.10–2.66)	0.02
Pre-operative anaemia	1.84 (1.20–2.81)	<0.001
Pre-operative dementia	1.47 (1.05–2.07)	0.03
Delayed surgery	0.95 (0.67–1.35)	0.79

*Each effect is adjusted for every other effect.

Table 3 Association between number of days at home (among patients who successfully returned to their home within 90 postoperative days) and baseline characteristics or peri-operative factors.

	OR* (95%CI)	p value
Age (ref: < 85 y)		0.01
85–89 y	0.79 (0.65–0.96)	-
>89 y	1.11 (0.91–1.37)	-
Male sex	0.94 (0.78–1.13)	0.52
ICU admission	0.83 (0.68–1.02)	0.08
ASA physical status score (ref: < 3)		0.17
3	0.81 (0.65–1.01)	-
≥4	0.82 (0.63–1.07)	-
Postoperative acute renal impairment	0.91 (0.72–1.15)	0.44
Pre-operative anaemia	0.89 (0.71–1.13)	0.35
Pre-operative dementia	2.52 (2.09–3.05)	<0.001
Delayed surgery	1.04 (0.87–1.23)	0.67

*Each effect is adjusted for every other effect.

Discussion

We evaluated the number of days alive and at home within 90 days of hip fracture surgery. We found that a third of our cohort either died or spent more than 90 days away from their home in hospital or a new care facility, and that even if they did eventually return home, patients often spent weeks to months away from their home. Due to the lengthy time away from home, we found the DAH₉₀ of greater value than the DAH₃₀ metric.

Our cohort were old, had significant comorbidity and were undergoing non-elective surgery; these are all risk-factors for complications, prolonged hospital stays and mortality [14, 18, 27, 28]. Our patients spent a median of 32

fewer days at home during the first 90 days compared with other studies that reported a median DAH₉₀ of about 86 days for a wide range of surgery in younger cohorts [11–13]. This difference was more pronounced at day 30, with a median DAH₃₀ of only 2 days compared with studies of other surgical cohorts with a median of 26 days [11–13]. After excluding those who died, the proportion of patients not returning home was 40% at 30 days and 19% at 90 days postoperatively, suggesting that there was a large number of patients who returned to their home after 30 days. With far fewer patients leaving hospital, DAH₃₀ is less likely to capture meaningful events, such as postoperative complications and re-admissions, than DAH₉₀. Furthermore,

most patients in our study who were admitted from their own home (rather than a nursing home) spent a significant period in subacute and rehabilitation wards in hospital. Only 38% of these patients returned home during the first 30 days, compared with 65% during the first 90 days, again supporting DAH₉₀ as the preferred metric for this patient group.

Consistent with previous studies [27–31], we found DAH₉₀ sensitive to risk factors for adverse surgical outcomes including postoperative complications, mortality and rehabilitation in hip fracture patients. Story et al. [32] reported that acute renal impairment with even a mild increase in serum creatinine of 20% or more was associated with a significant mortality risk in older adults undergoing a range of surgical procedures. Similarly, our study has also shown an association of reduced DAH₉₀ using this lower threshold of defining kidney injury. As such, we recommend using this lower threshold to define acute kidney injury for older surgical patients, which may alert clinicians to diagnose and treat otherwise unrecognised kidney injury in a timely manner.

Patient factors such as older age, male sex, presence of pre-operative anaemia and development of postoperative acute renal impairment were all associated with failing to return home. However, patients living with dementia were more likely to spend less time in hospital, usually returning to supported care, compared with those without dementia. Pre-operative dementia was associated with increased frequency of failure to return home; however, when they did return, patients with dementia actually had greater DAH₉₀. This may appear contradictory; however, over 80% of patients with dementia were admitted from a nursing home and returned there. Although living with dementia is a risk-factor for failure to return home, the level of care provided at their pre-operative residence, and possibly combined with limitations of medical treatment, may have led to earlier hospital discharge compared with those who lived in their own residence.

Despite having few modifiable risk-factors identified in this study, DAH₉₀ can be a useful communication tool to convey patients' risks of failure to return to their home after surgery. For the majority of older patients and their families, postoperative daily function, and being able to return to their home are the most important surgical outcomes [33]. Given the high-risk nature of these older adults, it is especially important to have discussions about goals of care and establish reasonable expectations. Hence, DAH₉₀ may be a useful decision aid for shared decision-making and informed consent tool for patients and clinicians.

Current research shows a lack of consensus regarding which outcomes should be reported for patients undergoing hip fracture surgery and how these outcomes should be defined and measured [34]. A core outcome set for patients undergoing hip fracture surgical procedures has been advocated [35], with the timing of surgery scored the highest as critical for inclusion in the future studies. However, the lack of consistent definitions and the heterogeneity in outcome measures have made it difficult for comparative effectiveness research to be conducted in this most-needed patient group [36]. For example, 'early surgery' is recommended in the current guidelines [37], but its definition varies from 6 to 72 h [38]. Although we could not demonstrate that DAH₉₀ gained benefit from early surgery, this is further evidence to support the call for consistent definitions and for standardising outcomes to be measured and reported, which plays a fundamental role in making comparative effectiveness research as well as future pooling of data possible. Accordingly, we propose to select from the recommended set of 10 core outcomes as secondary endpoints in all peri-operative trials that evaluate their effects on DAH₉₀ after hip fracture surgery [35].

Unlike previous studies that approximated length of stay of post-acute hospitalisation for different groups of surgical patients [12–14], we were able to accurately calculate individual days alive and at home based on their length of stay in post-acute care settings and record an accurate picture of most patients' care settings and durations after discharge. The exception was for the 37 patients who were lost to follow-up at hospital discharge. As they only accounted for a very small proportion of our cohort (4%), their data were used for descriptive statistics only, that is, days alive and at home results excluded these patients.

Moreover, we defined 'home' as the place where the patient usually resided before the index admission (nursing or own home) and a 'new care facility' where the patient received a higher level of care than that of pre-operative residence (new or upgraded nursing homes). This distinction is important as the pre-operative residential setting can have a significant effect on DAH₉₀. For example, most early discharges were in nursing home residents, whereas patients from their own home mostly had delayed discharges due to reduced nursing support at home.

Our specific definition of 'days alive and at home' incorporating both acute and subacute care as 'in hospital' and previous living situations, including supported care, as 'home' is unlikely to undermine days alive at home as a metric that is valid for assessing the effects of adverse events

on patient journeys. This is because we retained the three essential elements of length of stay away from home, re-admission from home and mortality [11–14].

Strengths of this study include the large sample of over 800 older adults using comprehensive data from our electronic medical records that encompasses both acute and subacute hospitals in a healthcare network. The majority of patients in our cohort were transferred postoperatively to a subacute setting within our network. This allowed for the collection of length of stay data in the post-acute setting, something which many previous similar studies were unable to obtain. There are some limitations of this study. It was a retrospective cohort study and it was susceptible to bias related to the inability to plan data collection in advance and to actively ensure data quality. Further, as our study is isolated to a single, medium-sized hospital network in metropolitan Australia, these results have uncertain generalisability. Despite having a comprehensive database, we were missing data for about 4% of patients, usually due to inter-hospital transfer. Finally, non-operative patients with hip fracture were not studied and thus our findings cannot be generalised to all patients with hip fracture. It is worth noting that, in this study, time in hospital for post-acute care or palliative care is not differentiated. However, based on the holistic nature of palliative care, Van Houtven et al. have proposed to count a day in a hospice as a day at home [39]. We support this notion and recommend that days alive and at home should include the time spent with end-of-life care in hospital.

We conclude that DAH₉₀ is a useful outcome metric for older adults undergoing hip fracture surgery and is more informative than DAH₃₀. We found that this cohort had substantially fewer days at home than other reported surgical groups. Further, in this population with high mortality, there was added value in examining survivors returning to supported care. We conclude that DAH₉₀ is a useful metric for clinical and health services research, quality science and goals of care discussions.

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Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. Peri-operative variables and definitions.

Figure S1. Timeline of patients' discharge journey and destination after surgery. * Postoperative acute or subacute care in hospital setting. † Post-acute care in hospital or a new care facility setting.