60% Reduction of reoperations and complications for elderly patients with hip fracture through the implementation of a six-item improvement programme

Tom Lian,1,2 Aleidis Brandrud,3 Lars Mariero,4 Lars Nordsletten,2,5 Wender Figved1,2

ABSTRACT

Introduction Hip fractures are common, serious and costly fractures in the elderly population. Several guidelines seeking to ensure best practice have been introduced. Although our institution complied with national guidelines for early surgery of hip fractures, no assessment of other evidence-based measures existed. We wanted to assess, test, implement and measure the impact of a quality improvement (QI) programme consisting of key elements proven to be important in the treatment of hip fractures.

Methods We formed a multidisciplinary QI team, consisting of several specialists in different fields. The QI team assessed multiple possible process measures for inclusion in the programme and selected six measurable interventions for implementation: early surgery, correct administration of prophylactic antibiotics, surgery using proven methods and expertise, a multidisciplinary patient pathway and secondary fracture prevention. The improvement process was monitored by a statistical process control chart (SPC). Complications, reoperations and mortality were compared before (n=293) and after (n=182) the intervention.

Results The SPC analyses indicated increasing adherence with all interventions throughout the improvement programme, and sustainability 7 years later. The last four periods showed a stable adherence above 90%. We found 60% reduction in major complications after the implementation of the improvement programme, from 19.1% to 7.7% (HR: 0.38 (95% CI: 0.23 to 0.61, p=0.0007). The need for reoperations due to complications fell from 12.6% to 4.9% (HR: 0.37 (95% CI: 0.21 to 0.67, p=0.0054). We did not find a difference in post-operative mortality after the implementation of the QI programme (HR: 0.95 (95% CI: 0.74 to 1.2, p=0.645).

Conclusion Our multiprofessional improvement programme achieved almost full adherence within 2 years and was sustainable 7 years later. The quality and safety of the care process were improved and led to a substantial and sustainable decrease in complications and reoperations.

INTRODUCTION

Hip fractures are common, serious and costly fractures in the elderly population, and the global prevalence is expected to increase to about 4.5 million in 2050.1 Because of the scale and the seriousness of the problem, several guidelines for treatment of hip fractures aiming to ensure best practice have been introduced.2–6 We know that prophylactic antibiotics administered correctly have a major impact on infection risk, and is the single most important measure against surgical site infections.7–9 Early surgery (<36 to 48 hours from hospital admission) is another key element in most guidelines, and is shown to reduce mortality for geriatric patients with hip fractures.10 11 Other elements in most guidelines are experienced surgeons (three or more years of experience), proven implants, and the use of bone cement in arthroplasty treatment in the elderly, which all have shown reduced reoperation rates.12–17 Comprehensive geriatric care (CGA) improves outcomes for frail older patients18 19 and after orthogeriatric care was introduced in the UK, the mortality among hip fracture patients has decreased.20 21 Strong evidence supports use of an interdisciplinary care programme for patients with hip fractures.19 20 22 Orthogeriatric care teams are comprised of a team of professionals specialised in treatment of elderly patients. The composition of the team may vary, but usually contains a geriatrician, an orthopaedic surgeon, a nursing staff trained in geriatrics, physiotherapists, occupational therapists, clinical pharmacologists, and in some cases a nutritionist and a social worker.

For secondary fracture prevention, a Fracture Liaison Service (FLS)23 aiming to identify and treat patients with a fragility fracture, and acting as the link between the patient, the orthopaedic team and the primary care system, is recommended.24 25 Adherence with evidence-based guidelines is likely to reduce complications and the need for reoperations, as well as decrease
postoperative mortality rates. However, adherence with guidelines varies, representing unwarranted variation in treatment with increased risk of poor outcomes.\textsuperscript{16–28} The challenge is to standardise when possible, without removing the complexity of each patient from the process.\textsuperscript{29} To prevent undesired variation, some countries measure and publish national quality indicators and outcomes from hospitals as an incentive to increase adherence to their national guidelines.\textsuperscript{30,31}

Our hospital is a general hospital in Norway for a local population of approximately 200,000 inhabitants, and the only hospital in this area with an emergency ward. Prior to the intervention, the orthopaedic department had performed and participated in several clinical trials on treatment of hip fractures, but no improvement programme had been conducted for this patient group. Although we knew our institution complied with national quality indicators for early surgery of hip fractures within 48 hours of admission, no assessment of other evidence-based measures existed. This knowledge gap led one of our senior staff members to initiate an improvement programme examining important processes in the treatment of hip fracture patients. We wanted to achieve sustainable improvement to the treatment pathway for elderly hip fracture patients by implementing a quality improvement (QI) programme based on evidence-based best practice elements. The improvement programme was designed so that all elements should be measurable and would represent an evidence-based substantial improvement if accomplished. To achieve such an improvement, we worked to involve all groups participating in the care of our patient group. With all involved parties feeling ownership to the treatment, we aimed to achieve long-term adherence to the new processes. Our overall goal was to improve the quality and safety of the care process with our QI programme, thereby reducing the rate of complications, reoperations and mortality in this frail patient group.

### METHODS

#### Quality improvement initiative

**Background**

The improvement programme was initiated by a senior staff member, anchored in hospital management and the different professions involved in the processes, and received improvement guidance from both internal and external experts when needed. Sustainability was promoted by distribution and visualisation of control charts on programme adherence, accompanied by supporting leadership comments. Continual information about best practice was provided by recognised professionals leading the improvement processes in a way that made sense to the different environments. We formed a multidisciplinary QI team consisting of an orthopaedic surgeon, orthopaedic and geriatric nurses, two representatives from the hospital trusts’ quality improvement department, a physiotherapist, a geriatrician and an external reviewer with experience from previous QI teams. For the first 6 months, a management consulting firm with experience in QI work in healthcare conducted workshops with the QI team. The QI team assessed and discussed multiple possible process measures for inclusion in the programme and selected six based on three criteria: (1) whether a best practice is established, (2) whether an effect is substantial if there is a gap that is closed, and (3) measurability (figure 1).

**The pilot**

The QI team performed a pilot study examining 101 consecutive patient records to assess the baseline situation for these six process measures, performed interviews with key personnel, and then started developing the improvement programme. Based on the pilot study and interviews, we learnt that some programme elements were in place but not systematically measured, and several elements were not implemented at all. In light of the results of the pilot study, action was taken to close the gap.

![Interventions in the improvement programme](image-url)
between current and best practice. Our intervention was conducted by a systematic approach of Plan-Do-Study-Act (PDSA)-cycles: Planning the changes, Doing (testing before implementing) the changes and measurements according to the plan, Studying the result, Acting on the findings, and Planning the next round, based on what we have learnt from the previous round of the cycle. The PDSA cycle is a well-known and commonly used improvement tool in healthcare settings, although its documented use in pragmatic clinical research has been rare. Each process was changed to best practice according to evidence found in the literature and national guidelines. The target processes were monitored by a checklist and displayed by a control chart. After a review of the data in each PDSA cycle, we adjusted our approach accordingly to increase adherence.

The QI-program

The pilot study showed that the first two items, surgery within 48 hours and correct antibiotic prophylaxis, were well established beforehand, and were followed up by measuring sustainability of adherence together with the other programme items. The next two interventions were established by the department leadership: A department wide rule of cemented arthroplasty in place of uncemented was enforced, as well as two surgeons, one being a consultant (more than 6 years of experience), participating in all arthroplasty and complex fracture surgery. Implementing an orthogeriatric care pathway with an interdisciplinary team took time and depended on collaboration with the department of internal medicine who had participants in the QI team from the beginning. Financial support for one geriatrician and one occupational therapist was secured in Q1 2014. A secondary fracture prevention system based on the FLS model was established so that all six interventions were in place by April 2014.

The QI team met on a monthly basis and worked throughout 2013 and 2014 to assess implementation progress and evaluate the need for modifications of the checklist and the interventions. We wanted to study the improvement process over time by monitoring the healthcare professional adherence with the improvement programme by using a statistical process control chart (SPC). The programme was aimed at all hip fracture patients, and by the help of a checklist (figure 2), the programme was tailored to the individual patient’s situation.

Adherence to the improvement programme was measured before, during and after testing and implementing the different elements. In addition, since patients operated with hemiarthroplasty were subjected to all six improvements, they were selected for follow-up for outcome measures: complications, reoperations and time from index operation to death. The outcome measures

<table>
<thead>
<tr>
<th>Admitted: Date:</th>
<th>Time:</th>
<th>Activity</th>
<th>Evaluation</th>
<th>Notes and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation start: Date:</td>
<td>Time:</td>
<td>Executed</td>
<td>If yes</td>
<td>If no</td>
</tr>
<tr>
<td>Registered by (initials):</td>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Right</td>
</tr>
</tbody>
</table>

1. Early surgery

1) Operated within 48 hours?

2. Infection prevention

2a) Correct antibiotic prophylaxis prescribed?

2b) Time for each dose noted in chart?

2c) Each dose administered on time?

3. Surgical method


4. Surgeon experience

4) In complex fractures and arthroplasty: Operated by two surgeons, at least one senior?

5. Multidisciplinary approach

5a) Screened for inclusion in multidisciplinary care?

5b) Admitted in multidisciplinary part of ward?

5c) Assessed in multidisciplinary team meeting?

5d) Assessed by geriatrician?

6. Secondary fracture prevention

6a) Secondary fracture assessment performed?

6b) Medical osteoporosis prophylaxis administered or prescribed?

6c) Standardised phrase for secondary prevention assessment used in discharge report?

Figure 2 The checklist used for SPC measurements of compliance. SPC, statistical process control chart.
were collected in a before and an after group, the cut-off being the implementation of all six improvements.

Statistical process control
During the seven periods of the study, an individual chart for SPC (I-chart) was selected to display and understand the variations in the professional adherence over time with the six changes that were tested and implemented. The I-chart was updated and analysed by standard rules to detect any signal of special cause variation in the wake of the changes we were testing. Making patients safer also involves variation according to their individual needs. Therefore, we provided adherence scores only where the care had been tailored to the individual patient’s situation (figure 2). To assess the sustainability of the achievements from 2016, an additional SPC measurement was conducted in 2021.

Impact of QI initiative
Outcome measurements
To study the impact of the improvement programme, we compared the period for outcome measures before all items were implemented (January 2012–March 2014) with the period after April 2014–December 2015. To compare the two groups at baseline, we collected data by chart review on age, gender, ASA classification, diabetes, smoking, dementia, alcohol abuse, number of medications, body mass index (BMI) and operating time. We also investigated whether the patient lived in an institution, and if not, whether they had any form of aid in their home before the fracture. Finally, we examined the timing of surgery, dividing the day into the three main hospital shifts, morning, evening and night. Since a change from uncemented to cemented hemiarthroplasty was one of the six parts of the improvement programme, only patients with a dislocated femoral neck fracture, and therefore in need of a hemiarthroplasty, were chosen for investigation with regards to outcome. Patients with undislocated femoral fractures and pertrochanteric fractures were treated with osteosynthesis and were, thus, not eligible for outcome measurements although they received the five remaining parts of the programme.

Statistical analysis
Complications, reoperations and mortality were recorded up to 5 years after index operation. Survival curves were compared using log-rank (Mantel-Cox) test and reported as HRs with 95% CIs.

Missing data
BMI data were frequently missing, both in the admittance chart and the anesthesiology report. Only 323 of 476 charts (68%) contained weight and height of the patient. There were 98 (34%) missing in the before group and 55 (30%) in the after group. Other than BMI, we were able to attain complete data on all patients.

Patients and public involvement
This research was conducted without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient-relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

RESULTS
Quality improvement initiative
All patients operated with a hemiarthroplasty in the period from 2012 to 2015 were investigated for outcome. There were 293 in the before implantation of changes group, and 182 patients in the after implementation of changes group. Comparing the patient characteristics before and after the intervention, we found no major differences between the groups (table 1).

Statistical process control
At baseline adherence to our set of evidence-based improvements was 45%. The first measurement after implementation of our guidelines showed an improvement to 58%. In total, we found three significant shifts of level in the desired direction, by more than eight consecutive data points above the previous centre line in each change period, towards sustainable, almost full adherence to the QI programme. Seven years later, the improvements appeared to be fully integrated in the department’s treatment algorithm with 96% adherence (figure 3), without the need for further interventions from the QI team, thus indicating a sustainable improvement had been achieved.

Impact of the QI initiative
Outcome measurements
Our results showed a 60% reduction in major complications after the implementation of the improvement programme, from 19.1% to 7.7% (HR: 0.38 (95% CI 0.23 to 0.61, p=0.0007) (table 1, figure 4). The need for a new surgery because of a complication fell from 12.6% to 4.9% (HR: 0.37 (95% CI 0.21 to 0.67, p=0.0054) (table 1, figure 4). In the before group, 60% of the complications occurred before 30 days postsurgery, whereas 43% occurred within 30 days in the after group. We further examined the need for new surgery and found that 65% of the reoperations was performed within 30 days in the before group. In the after group, 22% was performed within 30 days. Regarding postoperative mortality, we were not able to show any difference (HR: 0.95 (95% CI 0.74 to 1.2, p=0.645) (figure 4).

Other effects of the program
With the implementation of two surgeons for all hemiarthroplasties, one being a consultant, we saw a change towards more surgeries being pushed from the night shift to the next morning. Before all interventions were implemented, 35 of 293 (11.9%) hemiarthroplasties were performed during the night shift, whereas only 8 of
Table 1  Patient characteristics, complications and reoperations

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Before intervention (n=293)</th>
<th>After intervention (n=182)</th>
<th>Hazard ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (SD)</td>
<td>83.2 (8.5)</td>
<td>83.5 (8.0)</td>
<td>–</td>
<td>0.69</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>94 (32.1 %)</td>
<td>49 (26.9 %)</td>
<td>–</td>
<td>0.23</td>
</tr>
<tr>
<td>Mean BMI (SD)</td>
<td>22.9 (4.2)</td>
<td>22.5 (3.7)</td>
<td>–</td>
<td>0.39</td>
</tr>
<tr>
<td>ASA 1, n (%)</td>
<td>4 (1.4 %)</td>
<td>2 (1.1 %)</td>
<td>–</td>
<td>0.87</td>
</tr>
<tr>
<td>ASA 2, n (%)</td>
<td>101 (34.5 %)</td>
<td>65 (35.7 %)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>ASA 3, n (%)</td>
<td>175 (59.7 %)</td>
<td>105 (57.1 %)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>ASA 4, n (%)</td>
<td>13 (4.4 %)</td>
<td>11 (6.0 %)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>ASA 5, n (%)</td>
<td>0 (0.0 %)</td>
<td>0 (0.0 %)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Mean number of prescribed drugs (SD)</td>
<td>4.9 (3.5)</td>
<td>4.8 (3.3)</td>
<td>–</td>
<td>0.86</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>24 (8.2 %)</td>
<td>16 (8.7 %)</td>
<td>–</td>
<td>0.82</td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td>38 (13.0 %)</td>
<td>17 (9.3 %)</td>
<td>–</td>
<td>0.22</td>
</tr>
<tr>
<td>Alcohol abuse, n (%)</td>
<td>12 (4.1 %)</td>
<td>5 (2.7 %)</td>
<td>–</td>
<td>0.42</td>
</tr>
<tr>
<td>Dementia, n (%)</td>
<td>71 (24.2 %)</td>
<td>35 (19.1 %)</td>
<td>–</td>
<td>0.20</td>
</tr>
<tr>
<td>From institution, n (%)</td>
<td>75 (25.6 %)</td>
<td>58 (31.7 %)</td>
<td>–</td>
<td>0.15</td>
</tr>
<tr>
<td>Living at home with aid, n (%)</td>
<td>68 (23.2 %)</td>
<td>44 (24.0 %)</td>
<td>–</td>
<td>0.35</td>
</tr>
<tr>
<td>Mean operating time, min (SD)</td>
<td>70 (24.6)</td>
<td>72 (15.3)</td>
<td>–</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Before intervention</th>
<th>After intervention</th>
<th>Hazard ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dislocation</td>
<td>26 (8.9 %)</td>
<td>8 (4.4 %)</td>
<td>0.48 (0.24 to 0.96)</td>
<td>0.066</td>
</tr>
<tr>
<td>Infection</td>
<td>9 (3.1 %)</td>
<td>2 (1.1 %)</td>
<td>0.32 (0.1 to 1.02)</td>
<td>0.12</td>
</tr>
<tr>
<td>Dislocation with infection</td>
<td>5 (1.7 %)</td>
<td>1 (0.5 %)</td>
<td>0.32 (0.62 to 1.66)</td>
<td>0.27</td>
</tr>
<tr>
<td>Periprosthetic fracture</td>
<td>14 (4.8 %)</td>
<td>3 (1.6 %)</td>
<td>0.34 (0.13 to 0.9)</td>
<td>0.074</td>
</tr>
<tr>
<td>Other</td>
<td>2 (0.7 %)</td>
<td>0 (0.0 %)</td>
<td>0.2 (0.01 to 3.42)</td>
<td>0.26</td>
</tr>
<tr>
<td>Total</td>
<td>56 (19.1 %)</td>
<td>14 (7.7 %)</td>
<td>0.38 (0.23 to 0.61)</td>
<td>0.0007</td>
</tr>
</tbody>
</table>

Reoperations

<table>
<thead>
<tr>
<th>Reoperation</th>
<th>Before intervention</th>
<th>After intervention</th>
<th>Hazard ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual mobility acetabular cup revision to prevent further dislocations</td>
<td>14 (4.8 %)</td>
<td>2 (1.1 %)</td>
<td>0.23 (0.08 to 0.62)</td>
<td>0.031</td>
</tr>
<tr>
<td>Soft tissue debridment with exchange of prosthetic heads</td>
<td>9 (3.1 %)</td>
<td>2 (1.1 %)</td>
<td>0.35 (0.11 to 1.19)</td>
<td>0.16</td>
</tr>
<tr>
<td>Osteosynthesis and/or change of femoral stem</td>
<td>8 (2.7 %)</td>
<td>3 (1.6 %)</td>
<td>0.6 (0.18 to 2.01)</td>
<td>0.44</td>
</tr>
<tr>
<td>Girdlestone (removal of implant)</td>
<td>6 (2.0 %)</td>
<td>2 (1.1 %)</td>
<td>0.53 (0.13 to 2.22)</td>
<td>0.43</td>
</tr>
<tr>
<td>Total</td>
<td>37 (12.6 %)</td>
<td>9 (4.9 %)</td>
<td>0.37 (0.21 to 0.67)</td>
<td>0.0054</td>
</tr>
</tbody>
</table>

183 (4.4 %) were performed at night during the period after implementation. This increased the need for more available time in the operating theatre during daytime, to maintain the time from admittance to surgery below 48 hours. To accommodate this, a surgical slot was reserved each morning specifically for hip fracture surgery. Because surgical slots are not infinite, this was at the expense of other surgeries and thereby patients.

**DISCUSSION**

Adherence to our six evidence-based improvements increased from 48% to 94% in the study period. We could also show sustainability of the whole process with 96% adherence 5 years after the project was finished. We found a 60% decrease in major orthopaedic complications. We also found a decrease of 61% in the need for a reoperation due to a complication. We could, however, not show a change in the overall death rate. This, we believe, is mainly due to the overall health condition in the patient group before the fracture. Almost 25% of our patients suffered from dementia, and over 60% were ASA 3 or higher at the time of surgery, indicating frailty before the fracture. We, however, argue that all of the complications investigated have a major impact on quality of life for the individual patient as well as being highly expensive for the hospital and, thus, the society. Therefore, we have reason to believe that our improvement programme has improved the quality and safety of the care of one of our most fragile and vulnerable patient groups as well as cutting healthcare costs.

The most serious complications after hip fracture surgery are dislocations, periprosthetic fractures, deep infections and death. Reporting on complication rates varies in the literature ranging from 12.5% to 75%. 

Figure 3  I-chart showing per cent compliance of the improvement programme, before, during and after the changes were tested and implemented. The graph shows consecutive hip fracture patients according to date of surgery in eight measurement periods, indicating three significant shifts of level in the desired direction in period 2, 3.

but differences in how and which complications are reported make it difficult to compare results. Most traditional studies, and all randomised controlled trials, focus on singular risk factors out of many, after hip fracture surgery. In this study, we wanted to release the full might of the quality improvement toolbox. A major strength in using this quality improvement strategy, and underpinning the interventions by recognised improvement knowledge, is making it possible to change multiple processes during a short period of time. We also chose interventions that were to some degree interrelated, yielding a likely positive synergistic effect.

A major strength in our study is the use of continual measurements of adherence with the programme and using PDSA cycles for tweaking the processes when necessary. We can, therefore, know with certainty that the changes in the treatment pathway were being followed, and a direct correlation with the improvement programme and the decrease in complications can be derived. We were also able to follow the new processes towards almost certain sustainability 7 years later, showing that the changes had been integrated in our standard care of hip fracture patients.

When implementing large-scale changes to any system, there are several factors that need to be considered. Anchoring in management is essential, without which change is impossible. The next step is creating a shared understanding of the rationale behind the changes among all staff involved in the system. Therefore, the changes needed to be evidence based and continually taught. Finally, one or several champions for the cause are needed to properly explain, correct and follow-up the changes until the processes are stable. In our opinion, our success is mainly due to the fact that we had all three of the above-mentioned elements in place. We had anchoring in the entire patient pathway management, we had understandable and evidence-based reasons for changing our processes, and we had champions for the cause following and explaining the processes for several years after their implementation. Our group worked continually to involve and educate all groups involved in processes both directly and indirectly connected to care of patients with hip fracture. By conveying ownership to the processes involved to the individual healthcare professional groups, we aimed to, and succeeded, in achieving a sustainable improvement. By educating management, we were also able to make structural changes to our organisation with a day slot for hip fracture surgery and organisation of an orthogeriatric team and an FLS team. This eased rather than increase the burden on the individual staff member making the changes possible to implement and sustain.

**LIMITATIONS**

As with all QI studies, it is not possible to identify which intervention had the largest impact on our results. One could argue that one or two of the six interventions alone may have yielded the same results, but with two of the six interventions in place at baseline, we would argue that
Figure 4  Survival graphs comparing complications, reoperations and mortality between the period before and after all interventions were in place.

all of the interventions and the probable effect of the QI work itself, all have synergetic effects.

Overstandardising can increase risks for individual patients. Our approach to this was to allow for variation and grant points in the checklist when there was a medical reason for swaying from the programme. This opens for interpenetrations by the data recorders and, thus, bias issues.

Control charts are powerful tools for understanding the variation of a target process, but as the adherence data evolved to be more and more dichotomous during the improvement progress, the I-chart lost its power for analysing variation in periods 7 and 8. However, the chart is displaying an almost full adherence to the QI programme up to 7 years after the last changes were made. A p chart on the main adherence proportion per week would statistically have been more appropriate for this kind of data. However, the large amount of data to collect would have strangled the improvement process. We also did not set specific goals for adherence to our interventions before starting the study. In retrospect, we ask ourselves whether the QI work may have benefitted from clearly articulated adherence goals.

There is no consensus on what the best form of orthogeriatric treatment should be. Local adaptations are necessary, but there may be other more effective approaches for this group of patients, than ours. Some studies have managed to show reduced mortality rates with the implementation of an orthogeriatric treatment pathway. Why we could not, remains a question of interest to us.

CONCLUSIONS

Medical treatments are becoming more and more complex. There is an increasing need for a comprehensive and systematic approach to all individual patient treatment and pathways. In this QI project and study, we focused on a frail patient group of individuals with compound health issues, where margins are small and complications can be catastrophic. Known risk factors in hip fracture patients are intertwined, and, thus, the focus should be on all aspects of the treatment to prevent serious complications. The multidisciplinary approach with improvement efforts in several key areas following best practice is essential to provide optimal healthcare for these patients. We argue that our six interventions were interacting towards a synergistic effect, yielding an outcome that was better than the sum of its parts. The good results and the recognised improvement knowledge underpinning the intervention indicates its effectiveness and generalizability to other hospitals. However, the quality of the spread will depend on the other hospitals’ ability and patience to tailor the intervention to their particular context.

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Contributors TL and WF had the idea for the study and TL is the guarantor. WF had the idea for the improvement program, and it was started with the help from LM and AB. All authors contributed to the study design, writing, revising and improving the manuscript. TL carried out data collection. All authors contributed to data analysis and data interpretation. WF created all graphs. All authors contributed to the writing of the manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

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Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data that support the findings of this study are available from the corresponding author, [TL], upon reasonable request.

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