What makes the best performing hospital? the IQ Joint study

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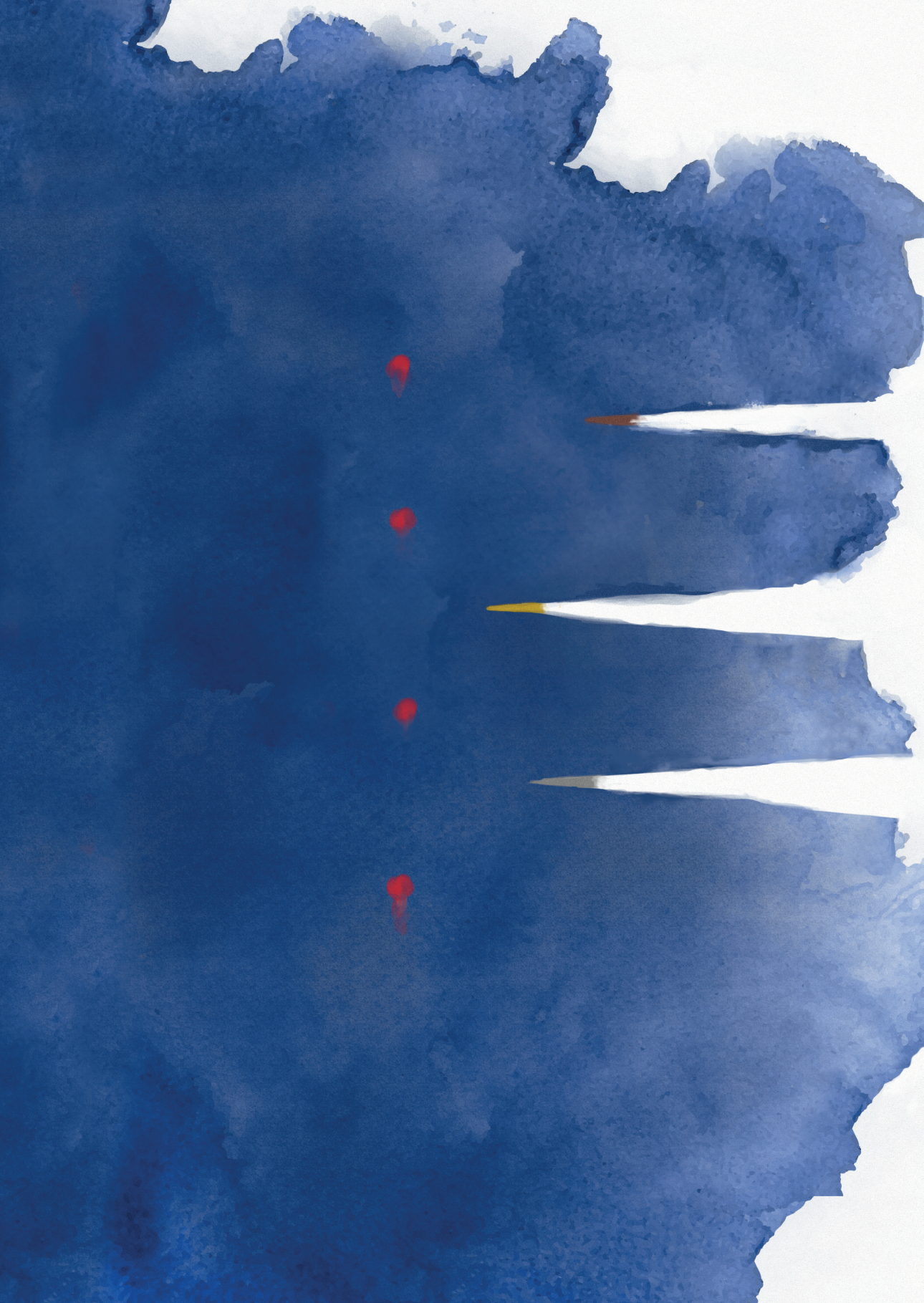

Chapter 7

Awareness of performance on outcomes after total hip and knee arthroplasty among Dutch orthopaedic surgeons: how to improve feedback from arthroplasty registries

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Abstract

Background and purpose

The Netherlands Registry of Orthopedic Implants (LROI) uses audit & feedback (A&F) as the strategy to improve performance outcomes after total hip and knee arthroplasty (THA/TKA). Effectiveness of A&F depends on awareness of below average performance to initiate improvement activities. We explored the awareness of Dutch orthopedic surgeons regarding their performance on outcomes after THA/TKA and factors associated with this awareness.

Methods

An anonymous questionnaire was sent to all 445 eligible Dutch orthopedic surgeons performing THA/TKA. To assess awareness on own surgeon group performance, they were asked whether their 1-year THA/TKA revision rates over the past 2 years were below average (negative outlier), average (non-outlier), above average (positive-outlier) in the funnel plot on the LROI dashboard or did not know. Associations were determined with 1) dashboard login at least once a year (yes/no); 2) correct funnel plots interpretation (yes/no) and; 3) recall of their 1-year THA/TKA revision rate (yes/no).

Results

44% respondents started the questionnaire, 158 THA and 156 TKA surgeons. 55% of THA surgeons and 55% of TKA surgeons were aware of their performance. Surgeons aware of their performance more often logged in on the LROI dashboard, more often interpreted funnel plots correctly and more often recalled their revision rate. 38% of THA and 26% of TKA surgeons scored good on all 3 outcomes.

Interpretation

Only half of orthopedic surgeons were aware of their performance status regarding outcomes after THA/TKA. This suggests that to increase awareness, orthopedic surgeons need to be actively motivated to look at the dashboard more frequently and educated on interpretation of funnel plots for audit and feedback to be effective.

Introduction

Several studies have shown large between-hospital variation in performance outcomes after total hip and knee arthroplasty (THA/TKA) including revision rates, suggesting opportunities to improve care (1-6). Audit and feedback (A&F) is a frequently used approach to reduce between-hospital variation, and defined as provision of clinical performance summaries to healthcare providers or organizations intended to initiate activities to improve performance (7,8). Worldwide, A&F from arthroplasty registries is provided in different ways. In the Netherlands, performance indicators such as revision rates, Patient Reported Outcome Measures (PROMs) and patient characteristics are shown on surgeon-group-level in a real-time password protected web-based dashboard and the extent of variation is shown in an anonymized version in annual reports.

Following a Cochrane review of 140 studies from multiple fields, A&F is effective with a median absolute improvement of 4% of the desired outcome, but with the effect size varying from a 9% decrease to a 70% increase (9). Part of the reason for this large variation in effectiveness may be the varying degree to which A&F leads to an increased awareness on own performance. For example, A&F is not received, information including graphs (e.g. funnel plots) and/or tables is not interpreted correctly, or the reported performance outcomes are not considered interesting (10). Sufficient awareness on own performance relative to others in combination with motivation to improve is more likely to result in targeted quality improvement initiatives (11-13).

Due to a lack of awareness on own performance, it is often overestimated (10). This can limit quality improvement initiatives, because it is assumed that performance is good even though there may be room for improvement. Furthermore, it is important that performance indicators give sufficient direction where to improve care, so that professionals are able to select focused interventions to improve care. A recent study showed that for most surgeon groups with significantly higher revision rates, the direction of improvement could be pointed out by looking at the reason for revision (e.g. infection, prosthesis loosening, dislocation etc.) (6). By looking at a more specific outcome, professionals can figure out in which part of the care process improvements are possible, e.g. timing of antibiotic prophylaxis (infection), cementation techniques (prothesis loosening) or femoral head size (dislocation).

We explored the awareness of orthopedic surgeons regarding their performance on outcomes after THA/TKA and factors associated with this awareness, to gain insight into the ways to increase the effectiveness of A&F provided by the LROI.

Methods

An anonymous internet-based questionnaire study was performed in December 2018 to explore the awareness of orthopedic surgeons on outcomes after THA/TKA provided by the LROI and associated factors.

Netherlands Registry of Orthopedic Implants (LROI)

The LROI was established in 2007 and in 2012 all Dutch surgeon groups participated. In 2015, the LROI dashboard was developed to allow surgeons to better monitor their performance showing information on the number of procedures performed, revision rates, PROMs and patient characteristics on surgeon group-level compared to other surgeon groups, which can be viewed at any time. The completeness for primary THA and TKA procedures is checked against Electronic Health Records and is currently above 98% for primary procedures and 96% for revisions (14,15). 97 surgeon groups performed THA and 98 performed TKA in the study period.

Study population

The questionnaire was sent to all 445 Dutch orthopedic surgeons performing primary THA/TKA, who were members of the hip and knee working groups from the Dutch Orthopedic Association. Reminders were sent by email 4 and 8 weeks after the first invitation. The survey was compiled using NetQ software (version 2014.Q3).

Survey

The information collected with the survey regarding the feedback provided on the LROI dashboard, is divided into 4 parts (Appendix, see Supplementary data).

In the first part, awareness regarding possible deviating performance (outlier status) of their own surgeon-group over the last 2 years was assessed by asking whether their 1-year revision rate was below average (negative-outlier), average (non-outlier), above average (positive-outlier) in the funnel plot on the LROI dashboard, or that they did not know. Second, we searched for 3 potential underlying factors that might be related to the level of awareness. It was assessed whether respondents 1) logged in at least once a year on their LROI-dashboard; 2) were able to interpret funnel plots correctly; 3) could recall the 1-year revision rate of their surgeon group. Respondents answering, they did not know were counted as giving a non-positive answer. By combining these 3 questions, a composite outcome was created. A respondent only scored ''good" when all 3 individual measures were positive, i.e. he/she logged in at least once a year, correctly interpreted the funnel plots and could recall their 1-year revision rate. We also asked about hospital work setting (university-, teaching-, general hospital or private clinic) and number of arthroplasties performed annually (<50,

50-100, >100). Third, respondents were asked about quality improvement initiatives following possible below average performance (negative-outlier) in the past 2 years, and whether the effects of these initiatives were checked using the available feedback information on the LROI dashboard. Finally, there were questions about perceived needs for changes in the current feedback, which current performance indicators were considered important, which indicators should be added to improve healthcare and the preferred frequency (every 1, 3, 6, or 12 months) and way of receiving feedback (tailored for their surgeon group or ability to make selections and explore the data oneself).

Statistics

Analyses were performed separately for THA and TKA surgeons. First, the proportion of respondents who were aware of deviating performance for their own surgeon group in the past 2 years was assessed. To examine the associations between awareness of deviating performance and the pre-defined potentially underlying factors (login to the dashboard, correct interpretation of funnel plots, recall of their own revision rate), univariate logistic regression analysis was performed. All questions answered by respondents regardless of whether they completed the full survey were included in the analyses. If surgeons stopped the survey but answered the previous question, we assumed there was a reason for stopping at that specific question (e.g. because it would be not acceptable to say not logging in) and coded this question as don't know, meaning these were included as non-positive answers. In addition, we examined whether the composite outcome differed across hospital settings and number of THA/TKA performed annually.

Data were analyzed with the statistical software of SPSS version 25. *P*-values <0.05 were considered statistically significant in all analyses.

Ethics, funding and potential conflict of interest

The LUMC Medical Ethical Committee waived the need for ethical approval under Dutch law (CME, G18.140). Author PvS received a grant from the Van Rens Foundation (VRF2018-001) to perform this study. The authors declare that there are no conflicts of interest.

Results

From 445 invited orthopedic surgeons, 194 (44%) started the survey, 158 surgeons performed THA and 156 TKA. 78 answered the questions within 4 weeks, 56 after the first and 60 after the second reminder. 169 (87%) respondents completed the survey (Figure 1). Median time to complete the survey was 6:4 minutes (Interquartile range: 5:3-8:5).

91% of respondents were male and 52% were between 40 and 50 years old. Most respondents (40%) were employed in a general hospital and evenly distributed across volume groups for THA and TKA (Table 1).

Table 1 Characteristics of the respondents.

	Respondents (*n*=194)	
	Frequency	**Percentage (%)**
Gender, male	177	91
Age (years)		
• <40	32	16
• 40-50	101	52
• 51-60	42	22
• >60	19	10
Hospital setting		
• University medical center	20	10
• Teaching hospital	72	37
• General hospital	78	40
• Private clinic	24	13
Type of surgeon*		
• Performing THA	158	81
• Performing TKA	156	80
• Performing THA & TKA	120	62
No. of THA per surgeon/year**		
• <50	34	21
• 50-100	75	48
• >100	46	29
• *No response*	3	2
No. of TKA per surgeon/year***		
• <50	37	24
• 50-100	78	50
• >100	32	20
• *No response*	9	6

* Does the respondent perform only THA, only TKA or both THA and TKA.

** There were 158 THA surgeons.

*** There were 156 TKA surgeons.

No. = Number; THA = Total Hip Arthroplasties; TKA = Total Knee Arthroplasties.

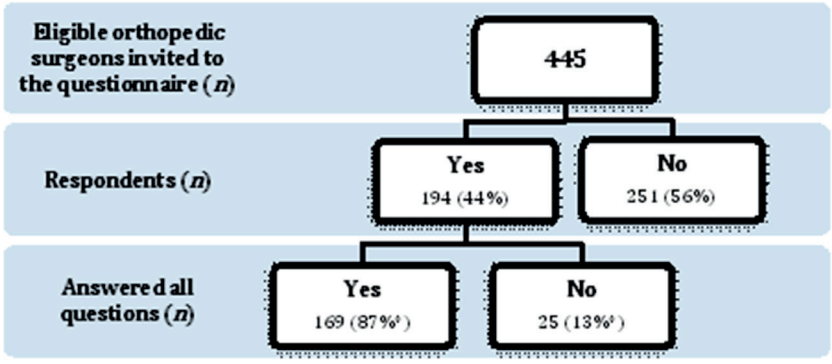


Figure 1 Respondence flowchart.
* Percentage of total number of respondents.

Awareness about performance and underlying factors (Table 2 and 3)

158 THA surgeons answered the questions on logging in, funnel plot interpretation and recalling their revision rate. Only 141 THA surgeons answered the questions on awareness of their surgeon-group performance, with 77 (55%) THA surgeons indicating to be aware of any deviating performance in their surgeon-group over the past 2 years. From the 158 THA surgeons, 105 (67%) logged in on the LROI-dashboard at least once a year, 96 (61%) interpreted the funnel plot correctly and 105 (67%) recalled their 1-year revision rate. THA surgeons who were aware of any deviating performance were 8 times more likely to log in, twice as likely to correctly interpret the funnel plot and 4 times more likely to recall their 1-year revision rate. Overall, 66 (38%) respondents scored good on all these individual items and thus on the composite outcome. THA surgeons who are aware of deviating performance were 5 times more likely to score good on the composite outcome.

156 TKA surgeons answered the questions on logging in, funnel plot interpretation and recalling their revision rate. Only 142 TKA surgeons answered the questions on awareness of own surgeon-group performance, with 78 (55%) TKA surgeons indicating awareness of any deviating performance in their surgeon-group over the past 2 years. Among the 156 TKA surgeons, 103 (66%) logged in to the LROI dashboard at least once a year, 95 (61%) interpreted the funnel plot correctly and 103 (66%) recalled their 1-year revision rate. TKA surgeons who were aware of any deviating performance were 4 times more likely to log in, twice as likely to correctly interpret the funnel plot and 5 times more likely to recall their 1-year revision rate. Overall, 41 (26%) respondents scored good on the composite outcome and TKA surgeons who are aware of deviating performance were 4 times more likely to score good on the composite outcome.

Table 2 Associations between awareness of surgeon-group performance and logging in to dashboard, correct funnel plot interpretation and knowledge about 1-year revision rate.

Yes		Logging in on LROI-dashboard*		Correct funnel plot interpretation**		Knowledge about 1-year revision rate***	
		No	Yes	No	Yes	No	
	All THA performing respondents (*n*=158)	105 (67%)	53 (33%)	96 (61%)	62 (39%)	105 (67%)	53 (33%)
THA Surgeons		**Yes**	**OR (CI)**	**Yes**	**OR (CI)**	**Yes**	**OR (CI)**
	Aware of surgeon-group performance						
	Yes (*n*=77)	69 (90%)	7.6 (3.2-18)	59 (77%)	2.4 (1.2-4.9)	66 (86%)	4.4 (2.0-9.8)
	No (*n*=64)	34 (53%)	*reference*	37 (58%)	*reference*	37 (58%)	*reference*

Yes		Logging in on LROI-dashboard*		Correct funnel plot interpretation**		Knowledge about 1-year revision rate***	
		No	Yes	No	Yes	No	
	All TKA performing respondents (*n*=156)	103 (66%)	53 (34%)	95 (61%)	61 (39%)	103 (66%)	53 (34%)
TKA Surgeons		**Yes**	**OR (CI)**	**Yes**	**OR (CI)**	**Yes**	**OR (CI)**
	Aware of surgeon-group performance						
	Yes (*n*=78)	65 (83%)	4.1 (1.9-9.0)	56 (72%)	1.6 (0.8-3.3)	66 (85%)	4.9 (2.2-10.7)
	No (*n*=64)	35 (55%)	*reference*	39 (61%)	*reference*	34 (53%)	*reference*

*Logging in at least once every year

**Correctly interpreted both funnel plots

***Know the 1-year revision rate of their healthcare center of the past 2 years.

CI = 95% confidence interval; OR = Odds ratio; THA = Total Hip Arthroplasty; TKA = Total Knee Arthroplasty.

Table 3 Composite outcome stratified by hospital setting and number of arthroplasties performed annually.

Yes (good)		Composite outcome	
		No	
	All THA performing respondents (*n*=158)	60 (38%)	98 (62%)
		Yes	**OR (CI)**
	Aware of surgeon-group performance		
	Yes (*n*=77)	46	5.3
	No (*n*=64)	14	*reference*
	Hospital setting (*n*=158)		
THA Surgeons	University medical center	4	0.4
	Teaching hospital	19	0.6
	General hospital	31	*reference*
	Private clinic	6	0.7
	No. of THA performed per year (*n*=155)*		
	<50	7	0.4
	50-100	35	1.4
	>100	18	*reference*

Yes (good)		Composite outcome	
		No	
	All TKA performing respondents (*n*=156)	41	115
		Yes	**OR (CI)**
	Aware of surgeon-group performance		
	Yes (*n*=78)	31	3.6
	No (*n*=64)	10	*reference*
	Hospital setting (*n*=156)		
TKA Surgeons	University medical center	2	0.3
	Teaching hospital	15	0.6
	General hospital	23	*reference*
	Private clinic	1	0.1
	No. of TKA performed per year (*n*=147)**		
	<50	7	2.4
	50-100	28	1.0
	>100	6	*reference*

*The number of THA performed per year by the respondent.
**The number of TKA performed per year by the respondent.
CI = 95% confidence interval; No. = Number; OR = Odds ratio; THA = Total Hip Arthroplasties; TKA = Total Knee Arthroplasties.

The proportion of surgeons who met the criteria of the composite outcome did not differ by the number of arthroplasties performed annually or across hospital settings, except for a lower proportion for TKA surgeons in private clinics.

Quality improvement initiatives

20 respondents indicated that they were employed in a healthcare center that had a significantly higher 1-year revision rate (negative-outlier) in the past 2 years. 9 of them

did not see this deviating performance coming, because they had never checked the LROI dashboard for performance indicators. 17 indicated that quality improvement initiatives had been introduced and all of them used performance indicators from the LROI dashboard to monitor the effect. A positive effect of these initiatives on the revision rate was reported by 9 respondents and a negative effect by 3 respondents when checking progress in the LROI dashboard. 5 respondents were currently following the effect.

Future feedback

From the current available performance indicators, the number of procedures performed was mostly considered as the most interesting information on the LROI dashboard, followed by 1-year revision rates, PROMs and patient characteristics respectively (Figure 2).

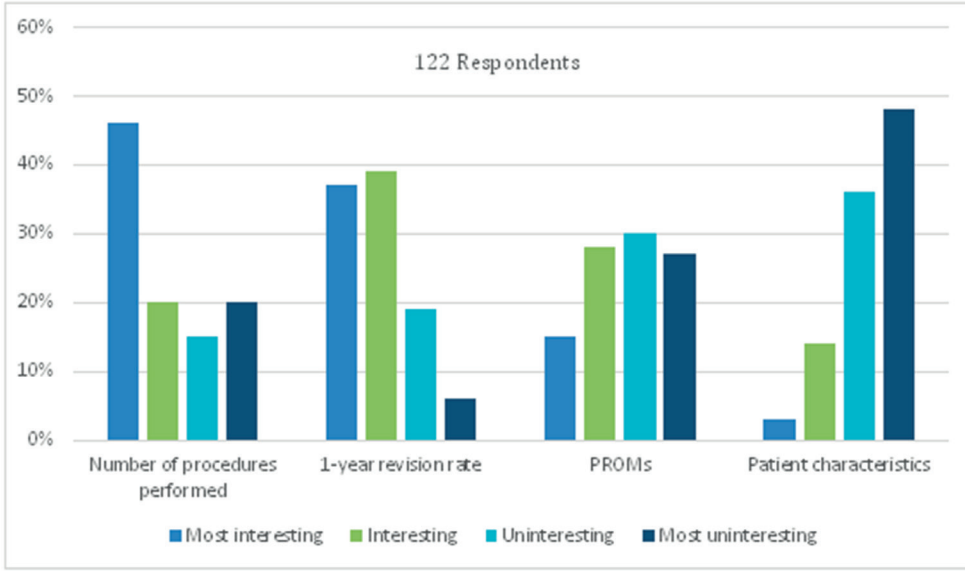


Figure 2 Currently available performance indicators on the secure LROI dashboard ranked from most to least interesting by respondents.
LROI = Dutch arthroplasty register; PROMs = Patient reported outcome measures.

Prosthesis survival and complications are currently not available on the LROI dashboard, but 138 (82%) THA surgeons and 129 (76%) TKA surgeons indicated this information to constitute relevant indicators (Figure 3). 106 (62%) respondents would prefer to receive feedback every 6 months, and a minority every month (*n*=6, 4%), every quarter (*n*=40, 23%) and some respondents having no preference (*n*=18, 11%). 139 (82%) respondents prefer feedback that is tailored for their surgeon-group

without making any selections and 30 respondents (18%) indicated to prefer making their own selections of LROI indicators.

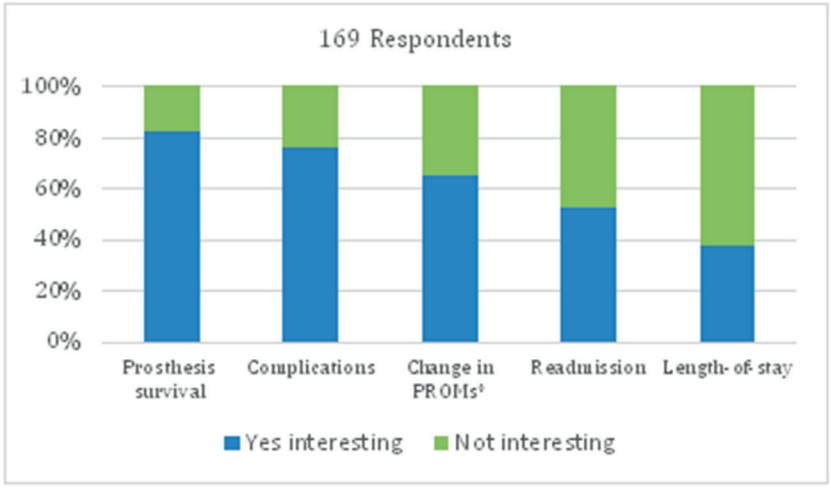


Figure 3 Percentage of orthopedic surgeons interested in additional performance indicators.
*Difference between pre- and post-operative PROMs
LROI = Dutch arthroplasty register; PROMs = Patient reported outcome measures.

Discussion

Although Dutch orthopedic surgeons performing THA/TKA can view their surgeon-group performance on a web-based A&F-dashboard, only half of them are actually aware of their performance over the past 2 years. This lack of awareness on own performance and the associations found in our study, suggests that orthopedic surgeons need to be actively motivated to log in more often, need to be educated on how to interpret funnel plots correctly and must be able to reproduce their revision rate for the A&F to be effective in improving care. To act upon the feedback information all underlying factors must be met, but this was the case in only one third of THA surgeons and one fourth of TKA surgeons, fairly similar across different types of hospitals and annual volume. Yet, it seems important to increase the effectiveness of feedback, given that 9 out of 20 respondents of the negative-outlier surgeon-groups indicated that they did not see their worsening performance coming. Without effective feedback, surgeon-groups would continue to provide care without modification, while 17 out of these 20 respondents indicated that they conducted quality improvement initiatives once identified as showing poor performance.

Differences and similarities between national arthroplasty registries in providing A&F

The way in which A&F is offered varies, from publicly available annual reports including only nationwide averages with sometimes additional surgeon-group specific performance, where others publish their indicators on surgeon-group-level and surgeon-level only in password-protected online dashboards (16-25). The LROI, National Joint Registry, United Kingdom (NJR) and Swedish Hip Arthroplasty Registries (SHAR) use a web-based password-protected A&F dashboard to provide surgeons with peer comparison indicators in visual graphs on surgeon-group-level and in the United Kingdom also on surgeon-level (16,17,25,26). In contrast, the Swedish Knee Arthroplasty Registries (SKAR) and the Danish Hip Arthroplasty Registries (DHAR) make no use of online dashboards, where the SKAR publishes only some indicators (e.g. patient demographics and PROMs) on their publicly accessible website once a year. Some arthroplasty registers may inform participating hospitals once a year about their performance e.g. by emailing performance indicators without this being listed on their website. The feedback generated by the NJR is updated every 6 months, which was also indicated as the preferred frequency to receive feedback by two thirds of respondents in our study (16,18). The Finnish Arthroplasty Registries (FAR), even uses a daily updated publicly accessible website, which includes patient demographics and revision rates at surgeon-group-level (17). What all these different methods of feedback have in common, is that it is passive education, not requiring any action which may be one of the explanations for orthopedic surgeons being unaware about their performance. Public availability of performance indicators may increase the likelihood of action being taken, given that both patients and other stakeholders like insurance companies can review the data and may use them in their decision making.

Comparison with literature

Besides the Cochrane review, there are more studies that found wide variation in the effect of A&F (9). A review, evaluating interactive computer feedback, found a highly variable effect of improvement in quality of care in 3 out of 7 studies (27). Another more recent study found a significant improvement for 4 out of 6 performance indicators, 2,5 years after implementation of online A&F interventions in maternal-new-born hospitals (28). Given the varying effect of A&F, the results of our study can make a relevant contribution to further improve current feedback as provided by arthroplasty registries. We have gained insight into whether A&F reached the target group (i.e. how often do surgeons log in), the ability to interpret the funnel plot and recall of revision rates. In addition, we investigated which performance indicators currently provided by the LROI are considered important by the target group and which indicators should be added. Furthermore, it would be useful to provide feedback on the reasons for revisions, given that this has been shown able to direct quality improvement

initiatives although, we did not specifically ask whether orthopedic surgeons would be interested in this information (6). 2 meta-analysis have shown that a single A&F strategy is one of the less effective interventions showing little to no improvement when examined (29,30). On the other hand, it seems obvious that accessible A&F that is interpreted correctly will ultimately improve the quality of care, as 17 out of 20 orthopedic surgeons indicated that they would conduct quality improvement initiatives as soon as they become aware of poorer performance. It seems likely that more active elements need to be added both to motivate orthopedic surgeons to log in and to ensure correct interpretation of the funnel plot, which is needed to be aware of outlier status regarding their performance.

Trust in A&F data quality is often identified as a barrier to change clinical behavior. This is unlikely to play a major role in the current LROI feedback given the 98% completeness for primary procedures and 96% for revisions, which is similar for the data in above mentioned arthroplasty registries (10-12,14). Another barrier may be that physicians do not consider some indicators as an essential part of quality or deem benchmarks unrealistic (10,31-35). In this study, for instance, it was found that one third of both THA and TKA surgeons do not know their 1-year revision rate, which may suggest that some surgeons do not recognize the importance of this outcome. This is striking because this outcome is already widely used by arthroplasty registries and considered an indicator to reflect the quality of care (17,19,20,22,24). Moreover, A&F does not use absolute benchmarks, but performance indicators are compared with national surgeon-group averages, thereby making it likely that other similar surgeon-groups are able to achieve that level of performance.

Strengths and limitations

A possible limitation of this study is response bias if awareness of performance differs between responders and non-responders and the association with underlying factors were to be different. Given that survey responses were collected anonymously, we were unable to compare whether the characteristics of the non-respondents differed from the respondents to assess whether bias may have occurred. However, considering the overall response rate of 44%, and the fact that non-respondents in general are not as involved as respondents and thus more likely to be not aware of their performance, the associations are likely underestimated. A second limitation, is that some self-reported outcomes (e.g. frequency of logging in or recall of revision rate) were analyzed. It is therefore possible that there were socially desirable answers to certain questions e.g. knowledge about certain indicators. If this affected the results, even fewer orthopedic surgeons may be aware of their performance. However, because this was an anonymous survey, it seems more likely that respondents are surgeons dedicated to good performance and making feedback information more useful rather than giving

socially desirable answers, so that reported rates are likely to reflect actual practice. An exception on the self-reported outcomes was the funnel plot interpretation, where answers given by respondents were compared with the correct answer so that social desirability was not an issue. A third limitation may be the generalization of our results to other countries. Increasingly information becomes publicly available on differences between hospitals in patient outcomes, as we have previously shown for revision rates in the Netherlands and Bozic et al (2014) have shown for complication rates after total hip and knee arthroplasty in the US (1,6). The magnitude of the between-hospital variation in risk-adjusted rates in these studies is surprisingly similar, with both studies showing about 3-4 fold differences between hospitals. Furthermore, although not looking at awareness in performance specifically, a previous international survey study showed only minor differences between orthopaedic surgeons operating in different continents, taking into account their demographics (e.g. sex, age), surgical experience (e.g. number of years in practice, number of arthroplasties performed per year), use of additional diagnostics (e.g. plain radiographs, CT, MRI) and final treatment chosen (e.g. surgical versus non-surgical) (36). So, there is no evidence to suggest that there would be smaller differences between surgeons regarding their performance in other countries, and a difference in awareness has to our knowledge not been described before. Yet, such difference in awareness may be crucial in explaining why hospital differences in performance continue to exist, rather than that public reporting of hospital differences will by itself result in improvement.

Implementation and further research

As alluded to above, more active elements need to be added to improve the A&F design to make it more attractive to log in and result in more awareness on own performance. This could be encouraged by emphasizing the importance of already available indicators (e.g. revision rates) and adding new indicators to the A&F dashboard that are considered relevant and of interest as reported in this study (prosthesis survival, complications, readmissions and length-of-hospital-stay). As a result, more surgeons may be actually reached by the feedback, because the number of orthopedic surgeons who log in as well as the frequency of logging in will then increase. In addition, teaching material must be available on how to interpret funnel plots and be actively promoted by the orthopedic association during meetings, which will also increase awareness and possibly increase the reach of feedback, when more surgeons can interpret the performance indicators. Ultimately, an increased awareness of one's own performance will likely lead to more quality improvement initiatives.

The question arises as to whether voluntary quality control by providing only passive A&F on performance is sufficient in modern orthopedic society. A&F could be more effective when offered in a more active and multifaceted way instead of a single element

(which in this study was only the LROI-dashboard) (9,37). A possible addition to the feedback would be that indicators are also verbally explained by an independent person, with clear targets discussed and action plans created, for instance based on a toolbox (7,9,11,38-44). In addition, setting up committees that will actively approach poorly performing hospitals to create action plans to improve quality of care, may increase interest in one's own performance as orthopedic surgeons want to avoid being under supervision. The Dutch Orthopedic Association has initiated up a quality committee in 2017 with the aim to detect negative outlier hospitals using LROI-data and discuss activities to improve care (45). This new procedure may stimulate logging in to check on performance and in this way increase awareness of own performance in the coming years. After all, orthopedic surgeons have no valid reason not to be interested in their own performance, given that they want the best care for their patients and continuously improving the quality of care is thus inherently linked to that.

This survey is part of the ''Improving Quality based on the Joint registries project" (IQ Joint study). Within this study, what will be tested includes whether more active intervention including monthly feedback on THA/TKA performance indicators, active education on how to use indicators for quality improvement, asking for improvement activities and linking hospitals with better performing hospitals to exchange information and find areas for improvement will result in better outcomes, fewer complications and more quality improvement initiatives compared to the LROI dashboard alone. During this randomized trial, A&F on surgeon-group-level will be provided according to the preferences of the orthopedic surgeons as has been evaluated in this study.

Conclusion

Orthopedic surgeons performing THA/TKA have limited awareness on performance of their surgeon-group. Awareness could be increased by encouraging them to log in more often on their A&F dashboard, teaching them how to interpret funnel plots and emphasizing the importance of performance indicators. Improvement of the effectiveness of feedback is important, because the majority of orthopedic surgeons indicated that quality improvement initiatives were introduced once they learned that their performance was worsening. To provide orthopedic surgeons with better feedback in the future, the feedback information should be extended with the indicators prosthesis survival and complications compared with peers at a national level, tailored to their specific surgeon-group rather than making any selections themselves, with 6-month frequency.

References

1. Bozic KJ, Grosso LM, Lin Z, Parzynski CS, Suter LG, Krumholz HM, et al. Variation in hospital-level risk-standardized complication rates following elective primary total hip and knee arthroplasty. J Bone Joint Surg Am. 2014;96(8):640-7.
2. Fry DE, Pine M, Nedza SM, Locke DG, Reband AM, Pine G. Risk-Adjusted Hospital Outcomes in Medicare Total Joint Replacement Surgical Procedures. J Bone Joint Surg Am. 2017;99(1):10-8.
3. Weeks WB, Kotzbauer GR, Weinstein JN. Using Publicly Available Data to Construct a Transparent Measure of Health Care Value: A Method and Initial Results. Milbank Q. 2016;94(2):314-33.
4. Siciliani L, Sivey P, Street A. Differences in length of stay for hip replacement between public hospitals, specialised treatment centres and private providers: selection or efficiency? Health Econ. 2013;22(2):234-42.
5. Menendez ME, Lu N, Huybrechts KF, Ring D, Barnes CL, Ladha K, et al. Variation in Use of Blood Transfusion in Primary Total Hip and Knee Arthroplasties. J Arthroplasty. 2016;31(12):2757-63.e2.
6. van Schie P, van Steenbergen LN, van Bodegom-Vos L, Nelissen R, Marang-van de Mheen PJ. Between-Hospital Variation in Revision Rates After Total Hip and Knee Arthroplasty in the Netherlands: Directing Quality-Improvement Initiatives. J Bone Joint Surg Am. 2019.
7. Ivers NM, Sales A, Colquhoun H, Michie S, Foy R, Francis JJ, et al. No more 'business as usual' with audit and feedback interventions: towards an agenda for a reinvigorated intervention. Implement Sci. 2014;9:14.
8. Brehaut JC, Eva KW. Building theories of knowledge translation interventions: use the entire menu of constructs. Implement Sci. 2012;7:114.
9. Ivers N, Jamtvedt G, Flottorp S, Young JM, Odgaard-Jensen J, French SD, et al. Audit and feedback: effects on professional practice and healthcare outcomes. Cochrane Database Syst Rev. 2012(6):Cd000259.
10. Gude WT, Roos-Blom MJ, van der Veer SN, Dongelmans DA, de Jonge E, Francis JJ, et al. Health professionals' perceptions about their clinical performance and the influence of audit and feedback on their intentions to improve practice: a theory-based study in Dutch intensive care units. Implement Sci. 2018;13(1):33.
11. van der Veer SN, de Keizer NF, Ravelli AC, Tenkink S, Jager KJ. Improving quality of care. A systematic review on how medical registries provide information feedback to health care providers. Int J Med Inform. 2010;79(5):305-23.
12. de Vos Maartje LG, van der Veer SN, Graafmans WC, de Keizer NF, Jager KJ, Westert GP, et al. Process evaluation of a tailored multifaceted feedback program to improve the quality of intensive care by using quality indicators. BMJ quality & safety. 2013;22(3):233-41.
13. Davis DA, Mazmanian PE, Fordis M, Van Harrison R, Thorpe KE, Perrier L. Accuracy of physician self-assessment compared with observed measures of competence: a systematic review. JAMA. 2006;296(9):1094-102.
14. van Steenbergen LN, Denissen GA, Spooren A, van Rooden SM, van Oosterhout FJ, Morrenhof JW, et al. More than 95% completeness of reported procedures in the population-based Dutch Arthroplasty Register. Acta Orthop. 2015;86(4):498-505.
15. *LROI website. Completeness of Registering Hospitals and Completeness of Registered Arthroplasties in the LROI Based on the Hospital Information System in 2016,* http://www.lroi-rapportage.nl/data-quality-coverage-and-completeness, accessed febr 2019.

16. Porter M, Armstrong R, Howard P, Porteous M, Wilkinson JM. Orthopaedic registries - the UK view (National Joint Registry): impact on practice. EFORT Open Rev. 2019;4(6):377-90.
17. Tabak AY, Bicimoglu A, Celebi L, Muratli HH, Yagmurlu MF, Aktekin CN. Early results of revision total hip replacements that used self locking revision stem (Wagner stem). [Turkish]. Artroplasti Artroskopik Cerrahi. 2002;13(2):65-72.
18. Assi CC, Barakat HB, Caton JH, Najjar EN, Samaha CT, Yammine KF. Mortality Rate and Mid-Term Outcomes of Total Hip Arthroplasty Using Dual Mobility Cups for the Treatment of Femoral Neck Fractures in a Middle Eastern Population. J Arthroplasty. 2019;34(2):333-7.
19. Bonutti PM, Khlopas A, Chughtai M, Cole C, Gwam CU, Harwin SF, et al. Unusually High Rate of Early Failure of Tibial Component in ATTUNE Total Knee Arthroplasty System at Implant-Cement Interface. J Knee Surg. 2017;30(5):435-9.
20. Itonaga I, Sabokbar A, Murray DW, Athanasou NA. Effect of osteoprotegerin and osteoprotegerin ligand on osteoclast formation by arthroplasty membrane derived macrophages. Ann Rheum Dis. 2000;59(1):26-31.
21. Kurcz B, Lyons J, Sayeed Z, Anoushiravani AA, Iorio R. Osteolysis as it Pertains to Total Hip Arthroplasty. Orthop Clin North Am. 2018;49(4):419-35.
22. Li TF, Santavirta S, Virtanen I, Könönen M, Takagi M, Konttinen YT. Increased expression of EMMPRIN in the tissue around loosened hip prostheses. Acta Orthop Scand. 1999;70(5):446-51.
23. Pelt CE, Stagg ML, Van Dine C, Anderson MB, Peters CL, Gililland JM. Early outcomes after revision total hip arthroplasty with a modern modular femoral revision stem in 65 consecutive cases. Arthroplasty today. 2019;5(1):106-12.
24. Talmo CT, Anderson MC, Jia ES, Robbins CE, Rand JD, McKeon BP. High Rate of Early Revision After Custom-Made Unicondylar Knee Arthroplasty. J Arthroplasty. 2018;33(7s):S100-s4.
25. Yoon C, Chang MJ, Chang CB, Choi JH, Lee SA, Kang SB. Does unicompartmental knee arthroplasty have worse outcomes in spontaneous osteonecrosis of the knee than in medial compartment osteoarthritis? A systematic review and meta-analysis. Arch Orthop Trauma Surg. 2019;139(3):393-403.
26. Toomey SD, Hopper RH, Jr., McAuley JP, Engh CA. Modular component exchange for treatment of recurrent dislocation of a total hip replacement in selected patients. J Bone Joint Surg Am. 2001;83(10):1529-33.
27. Tuti T, Nzinga J, Njoroge M, Brown B, Peek N, English M, et al. A systematic review of electronic audit and feedback: intervention effectiveness and use of behaviour change theory. Implement Sci. 2017;12(1):61.
28. Weiss D, Dunn SI, Sprague AE, Fell DB, Grimshaw JM, Darling E, et al. Effect of a population-level performance dashboard intervention on maternal-newborn outcomes: an interrupted time series study. BMJ quality & safety. 2018;27(6):425-36.
29. Shojania KG, Ranji SR, McDonald KM, Grimshaw JM, Sundaram V, Rushakoff RJ, et al. Effects of quality improvement strategies for type 2 diabetes on glycemic control: a meta-regression analysis. JAMA. 2006;296(4):427-40.
30. Tricco AC, Ivers NM, Grimshaw JM, Moher D, Turner L, Galipeau J, et al. Effectiveness of quality improvement strategies on the management of diabetes: a systematic review and meta-analysis. Lancet. 2012;379(9833):2252-61.
31. Gude WT, van Engen-Verheul MM, van der Veer SN, de Keizer NF, Peek N. How does audit and feedback influence intentions of health professionals to improve practice? A laboratory experiment and field study in cardiac rehabilitation. BMJ quality & safety. 2017;26(4):279-87.

32. van der Veer SN, de Vos ML, Jager KJ, van der Voort PH, Peek N, Westert GP, et al. Evaluating the effectiveness of a tailored multifaceted performance feedback intervention to improve the quality of care: protocol for a cluster randomized trial in intensive care. Implement Sci. 2011;6:119.
33. Eva KW, Armson H, Holmboe E, Lockyer J, Loney E, Mann K, et al. Factors influencing responsiveness to feedback: on the interplay between fear, confidence, and reasoning processes. Adv Health Sci Educ Theory Pract. 2012;17(1):15-26.
34. Gude WT, van der Veer SN, de Keizer NF, Coiera E, Peek N. Optimizing Digital Health Informatics Interventions Through Unobtrusive Quantitative Process Evaluations. Stud Health Technol Inform. 2016;228:594-8.
35. Catelas I, Lehoux EA, Ning Z, Figeys D, Baskey SJ, Beaulé PE. Differential proteomic analysis of synovial fluid from hip arthroplasty patients with a pseudotumor vs. Periprosthetic osteolysis J Orthop Res. 2018;36(7):1849-59.
36. Li CS, Karlsson J, Winemaker M, Sancheti P, Bhandari M. Orthopedic surgeons feel that there is a treatment gap in management of early OA: international survey. Knee Surg Sports Traumatol Arthrosc. 2014;22(2):363-78.
37. Soong C, Shojania KG. Education as a low-value improvement intervention: often necessary but rarely sufficient. BMJ quality & safety. 2020;29(5):353-7.
38. Brehaut JC, Colquhoun HL, Eva KW, Carroll K, Sales A, Michie S, et al. Practice Feedback Interventions: 15 Suggestions for Optimizing Effectiveness. Ann Intern Med. 2016;164(6):435-41.
39. Gude WT, Roos-Blom MJ, van der Veer SN, de Jonge E, Peek N, Dongelmans DA, et al. Electronic audit and feedback intervention with action implementation toolbox to improve pain management in intensive care: protocol for a laboratory experiment and cluster randomised trial. Implement Sci. 2017;12(1):68.
40. Bradley EH, Holmboe ES, Mattera JA, Roumanis SA, Radford MJ, Krumholz HM. Data feedback efforts in quality improvement: lessons learned from US hospitals. Qual Saf Health Care. 2004;13(1):26-31.
41. Bradley EH, Curry LA, Webster TR, Mattera JA, Roumanis SA, Radford MJ, et al. Achieving rapid door-to-balloon times: how top hospitals improve complex clinical systems. Circulation. 2006;113(8):1079-85.
42. Brown B, Gude WT, Blakeman T, van der Veer SN, Ivers N, Francis JJ, et al. Clinical Performance Feedback Intervention Theory (CP-FIT): a new theory for designing, implementing, and evaluating feedback in health care based on a systematic review and meta-synthesis of qualitative research. Implement Sci. 2019;14(1):40.
43. de Vos M, Graafmans W, Kooistra M, Meijboom B, Van Der Voort P, Westert G. Using quality indicators to improve hospital care: a review of the literature. Int J Qual Health Care. 2009;21(2):119-29.
44. Roos-Blom MJ, Gude WT, de Jonge E, Spijkstra JJ, van der Veer SN, Peek N, et al. Impact of audit and feedback with action implementation toolbox on improving ICU pain management: cluster-randomised controlled trial. BMJ quality & safety. 2019;28(12):1007-15.
45. CommisionQuality. Commision Quality (Collaboration between Dutch Orthopaedic Association and Dutch Arthroplasty Registry). Protocol: Quality procedure, 2017. www.orthopeden.org.

Supplemental data

Appendix Survey

In order to make the questionnaire run as efficiently as possible, a number of ''loops'' have been incorporated into the questionnaire, so that orthopedic surgeons do not have to answer questions that do not apply to them. These loops are indicated in the questionnaire.

Questions for all respondents: Surgeon-specific questions

1. What is your age in years?
   a. Under 40
   b. 40 to 50
   c. 51 to 60
   d. Above 60

2. What is your gender?
   a. Male
   b. Female

3. In what type of healthcare center do you work for the majority of your time? *(This question involves part 2, see methods section survey in article)*
   a. University hospital
   b. Teaching hospital
   c. General hospital
   d. Private clinic

4. Do you perform primary total hip arthroplasties and/or primary total knee arthroplasties?
   a. Yes, only hip arthroplasties → Loop I (questions 5,6, (skip questions 7,8))
   b. Yes, only knee arthroplasties → Loop II (questions 7,8 (skip questions 5,6))
   c. Yes, both hip- and knee arthroplasties → Loop I &II (questions 5,6,7,8)
   d. No → End of questionnaire

Loop I: Orthopedic surgeons performing Total Hip Arthroplasties

5. How many primary total hip arthroplasties do you perform annually? *(This question involves part 2, see methods section survey in article)*
   a. Less than 50
   b. 50 to 100

c. More than 100

Questions regarding the online LROI-dashboard for total hip arthroplasty

6. What was the overall 1-year revision rate of your department for total hip arthroplasties over the last 2 years? *(This question involves part 2, see methods section survey in article)*
   a. Worse than average
   b. Average
   c. Better than average
   d. I do not know

Loop II: **Orthopedic surgeons performing Total Knee Arthroplasties**

7. How many primary total knee arthroplasties do you perform annually? *(This question involves part 2, see methods section survey in article)*
   a. Less than 50
   b. 50 to 100
   c. More than 100

Questions regarding the online LROI-dashboard for total knee arthroplasty

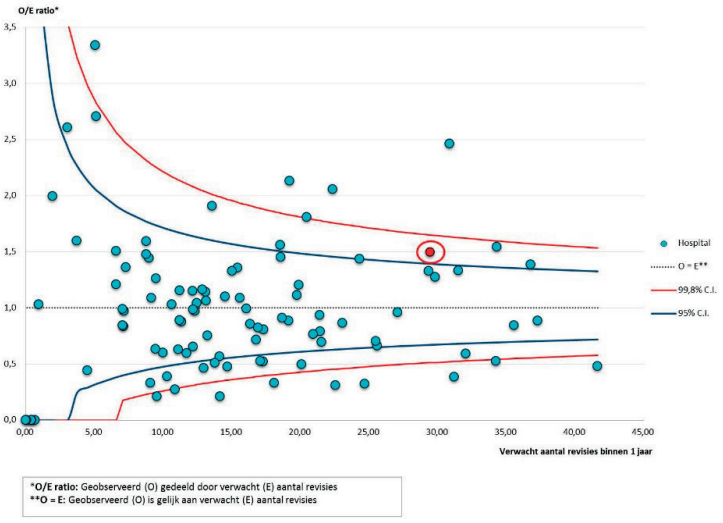
8. What was the overall 1-year revision rate of your department for total knee arthroplasties over the last 2 years? *(This question involves part 2, see methods section survey in article)*
   a. Worse than average
   b. Average
   c. Better than average
   d. I do not know

Questions for all respondents: Frequency of logging in on LROI-dashboard.

9. How often do you log in on the LROI-dashboard? *(This question involves part 2, see methods section survey in article)*
   a. Never
   b. Once a week
   c. Once a month
   d. Once per 6 months
   e. Once a year

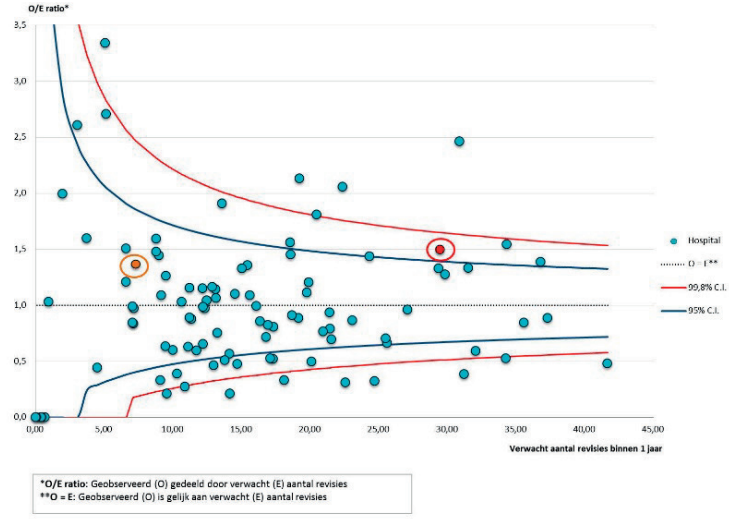
Questions for all respondents: Funnel-plot interpretation.

10. How does the department encircled with red perform? *(This question involves part 2, see methods section survey in article)*



a. Much worse than average (outside 99.8% control limit)
b. Worse than average (outside 95% control limit)
c. Average (within 95% control limit)
d. Better than average (outside 95% control limit)
e. Much better than average (outside 99.8% control limit)
f. I do not know

11. How does the department encircled with orange perform compared to the department encircled with red? *(This question involves part 2, see methods section survey in article)*



a. Better
b. Equal
c. Worse

Questions for all respondents: Awareness about performance of own healthcare center

12. Has your department, according to the funnel-plots displayed on the LROI-dashboard ever performed worse (above the 95% confidence interval) in the past two years? *(This question involves part 1, see methods section survey in article)*
    a. Yes → Loop III (question 13,14,15)
    b. No → Question 16
    c. I do not know → Question 16

Loop III: Worse than average performance based on the LROI-dashboard

13. Did you see in advance that your department performed worse than average? *(This question involves part 3, see methods section survey in article)*
    a. No,
    b. Yes, I felt this coming
    c. Yes, because we collect the same data as the LROI
    d. Yes, because my colleague drew my attention to this

14. Did you undertake quality improvement initiatives to improve? *(This question involves part 3, see methods section survey in article)*
    a. Yes, because we already knew what caused it
    b. Yes, after investigating the cause
    c. No, because the results may be due to coincidence and this is probably an one-off incident
    d. No, because in this period we were treating on a relatively difficult patient population. The results will therefore improve automatically
    e. No, other reason, namely…

15. Did you use the LROI-data to check whether the quality improvement initiative(s) have had effect(s)? *(This question involves part 3, see methods section survey in article)*
    a. No, we have not taken any action
    b. No, we did not check the effect of the intervention
    c. No, we introduced the intervention recently and are monitoring whether an effect is sorting
    d. Yes, the intervention(s) had no effect
    e. Yes, the intervention(s) had a positive effect

Questions for all respondents: Future improvements for feedback

16. Would you prefer to receive a signal earlier if the performance of your department improves or deteriorates compared to the national average? *(This question involves part 4, see methods section survey in article)*
    a. No, I can see that in the funnel-plot in the LROI-dashboard
    b. Yes, I would like an update every 6 months
    c. Yes, I would like an update every 3 months
    d. Yes, I would like an update every month

17. Which tabs on the LROI-dashboard interest you the most? Put the results in order from most interesting (1) to least interesting (4) by dragging the 'blocks". *(This question involves part 4, see methods section survey in article)*
    a. Total number of procedures performed
    b. 1-year revision rate
    c. PROMs
    d. Patient characteristics

18. Are there, in addition to the 1-year revision rates, in comparison with other healthcare centers, more outcomes in which you are interested (Yes/No)? You can check multiple options here. *(This question involves part 4, see methods section survey in article)*

a. Prosthesis survival
b. Improvement in PROMs postoperative compared to preoperative
c. Length-of-hospital-stay
d. Hospital readmission
e. Complications (other than revisions)
f. None

19. How would you like to receive feedback on the outcomes of your department? *(This question involves part 4, see methods section survey in article)*
    a. As the current situation, make selections on the LROI-dashboard
    b. Make selections on a mobile application
    c. Tailored for my surgeon-group, without making selections myself, on the LROI-dashboard
    d. Tailored for my surgeon-group, without making selections myself, on a mobile application
    e. Tailored for my surgeon-group, without making selections myself, send by email.