Exploring the black box of quality improvement collaboratives: modelling relations between conditions, applied changes and outcomes

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Abstract

Introduction: Despite their popularity in different health care settings, relatively little is known about implementation processes and effects of quality improvement collaboratives (QICs). Objective of the current study is to learn more about relations between relevant conditions for successful implementation of QICs, applied changes, perceived successes and performance indicators.

Methods: 24 Dutch hospitals participated in a dissemination programme based on QICs. A questionnaire was sent to 237 leaders of teams who joined 18 different QICs to measure changes in working methods and activities, overall perceived success, team organization and supportive conditions. Performance indicator outcomes were extracted from a database with team monitored data. Multilevel analyses were conducted to test several hypothesized relations within the cross-classified hierarchical structure wherein teams are nested within QICs and hospitals.

Results: Organizational and external change agent support are positively related to the number of changed working methods and activities that, if increased, lead to a higher perceived success and indicator outcomes scores. Positive relations between conditions could be confirmed, as well as between conditions and perceived success. Relations between conditions and performance indicators are weak. Multilevel analyses reveal significant differences in organizational support between hospitals. The relation between perceived successes and performance indicators is present at QIC level, not at team level.

Discussion: Besides confirming expected relations, the study adds an important insight to the knowledge about QICs. Perceived successes are a poor proxy for performance indicator outcomes of individual teams. At QIC level, instead, there is a strong relation. Since QICs vary in topic, approach, complexity and promised advantages, further research is required. Firstly, to understand why some QIC innovations fit better within the context of the units where they are implemented. Secondly, to assess the influence of perceived success and indicator outcomes on the further dissemination of projects over new patient groups.

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Introduction

In the last decade many countries have initiated quality improvement collaboratives (QICs) in health care settings. QICs bring together groups of practitioners from different healthcare organizations to work in a structured way to improve one aspect of the quality of their service. It involves them in a series of meetings to learn about best practice in the area chosen, about quality methods and change ideas, and to share their experiences of making changes in their own local setting.[1] Another important feature of collaboratives is the use of continuous quality improvement methods to realize changes. Continuous quality improvement is a proactive philosophy of quality management featuring multidisciplinary teamwork, team empowerment, an iterative approach to problem solving and ongoing measurement.[2,3] QICs are presented as 'arguably the health care delivery industry's most important response to quality and safety gaps', representing substantial investments of time, effort, and funding.[4] Yet, the problem is that despite their popularity, the evidence for QIC effectiveness is rather scarce.[3,4,5] Therefore researchers urge for more research into the different types of QICs and their effectiveness, as well as linking QIC practices explicitly to organizational and change management theory.[1,4,6,7,8] Or as stated by Cretin *et al.*: it is important to open the 'black box' of QIC implementation.[3]

The current study intends to contribute to a better understanding of processes and outcomes within a change programme for 24 Dutch hospitals based on QICs. *Better Faster pillar 3* is a national programme based on different breakthrough collaboratives (box 1) in the areas of patient safety and logistics. The patient safety targets involve pressure ulcers, medication safety and postoperative wound infections. Logistics teams deal with operation theatre productivity, throughput times, length of in-hospital stay and access time for out-patient appointments (for details see table 1).

INSERT BOX 1 and TABLE 1

Relations between conditions, applied changes and outcomes

In this study the focus was on the relations between relevant conditions for successful QIC implementation, changes in working methods and activities, and patient related outcomes. In opposite

order, the outcomes involve perceived project successes and actual progress made in the area of patient safety and logistics. Changes in working methods and activities have to do with all the new or intensified efforts taken by the teams on behalf of their project since they joined the QIC. The conditions can be derived from literature on implementation and dissemination of innovations in health services organizations. This knowledge base contains many descriptions of success factors that are linked to the tasks and responsibilities of the actors involved in QIC efforts.[12,13]

Implementation of innovations implies transferring knowledge about improvement methods from external change agents to the teams. This knowledge is to be implemented in some sort of supportive environment. Therefore conditions can be divided into three categories: 1) the organization of the multidisciplinary teams who join a QIC and transform the knowledge into action, 2) the degree of support these teams get from their hospital organization, and 3) the support given by the external consultants/change agents who facilitate the QIC and its meetings.[14]

Team organization affects the teams joining a QIC. Cohen and Bailey defined a team as 'a collection of individuals who are interdependent in their tasks, who share responsibility for outcomes, who see themselves and who are seen by others as an intact social entity embedded in one or more larger social systems (for example, business unit or corporation), and who manage their relationships across organizational boundaries' (p. 241).[15] There is a general consensus in the literature that a team consists of at least two individuals, who have specific roles, perform interdependent tasks, are adaptable, and share a common goal.[16] To increase team effectiveness it is important to establish timely, open and accurate communication among team members.[17] The notion that QIC teams are responsible and in charge of project progress [1] is in line with literature suggesting that operational decision making during implementation processes should be devolved to teams.[18]

Internal support. Other imperatives for team success are strong organizational support and integration with the organization's key values.[19] Within QICs internal or organizational support has to do with leadership, support and active involvement by top management.[20,21,22] Regular contact is needed between team and organization leaders, and the innovation must fit within the goals of the management.[22] Øvretveit *et al*. state that topics should be of strategic importance to the organization.[1] Besides the presence of necessary means and instruments [23] many of the internal

support tasks are to be executed by the strategic management. Executives have to communicate a vision or key values throughout the organization.[24,25] They must stimulate the organization's and employee's willingness to change.[26,27] These tasks fall within the priority setting areas defined by Reeleeder *et al*. i.e. foster vision, create alignment, develop relationships, live values and establish process.[28]

External support. The involvement of external change agents, arranging group meetings for teams of different organizations, is a typical QIC feature. The purpose is that teams are empowered and motivated to implement new working methods in order to alter a quality aspect of their care delivery. External change agents should provide teams with an applicable model together with appealing performance expectations.[29] This implies and requires a gap between a desirable and an actual situation, as well as outlining the potential added value of the innovation to the teams.[1] A second prerequisite is that teams joining the QIC have to gain information and skills that are new to them, otherwise an important argument for joining the QIC is void. The external support dimension is connected to the other two dimensions. The central topics of the collaboratives organized by the external change agents can be seen as the innovations that will determine team focus during the implementation process. The nature of these innovations should be aligned with organizational key values. Although highly simplified, this is the mechanism by which new working methods are brought into the organizations of the QIC teams via the external change agents.

Testing five types of relations

In this article a model will be tested based on a number of expected relations between the conditions, team initiated changes based on new knowledge and two outcome measures (figure 1). The model consists of five types of hypothesized relations. Relation a: if an outcome indicator shows that a project's main topic is improved, a project leader is more likely to be positive about the success of the project. Or the other way around, if the team leader thinks positive about the project's result this may indicate that the project actually led to improvement. Relation b: positive relations between the conditions are more probable than negative relations; negative perceptions about team organization coinciding with positive perceptions of internal and external support are not logical. It is for the same

reason that better outcomes – perceived success and performance indicator scores - are likely to be accompanied by higher satisfaction about internal and external support and team functioning (relation c). Moreover, the number of new or intensified improvement methods and activities is expected to be higher if the conditions for success during the implementation – team organization and organizational and external support – are appreciated higher; 'more is done if relevant conditions are available' (relation d). New or intensified improvement methods and activities, finally, should have a positive effect on outcomes and perceived presence of conditions; 'when more is done, outcomes should be better' (relation e).

Two research questions

Aim of this study is to answer two questions:

1) To what extent do the expected relationships between conditions, applied changes, perceived degree of success and indicator outcomes exist?
2) Can differences in conditions and outcomes be explained by the fact that the teams belong to different QICs and hospitals?

Methods

Project teams from three hospital groups started, one group after the other, in October 2004, October 2005 and October 2006 with the implementation of the QIC projects. Two data sources were accessed to gain information on six variables that were used for the purpose of statistical modelling.

Data sources and variables

The QIC team leaders served as a first data source. In January 2006, 2007 and 2008 the team leaders received a questionnaire at the end of the first year of implementation. The team leaders were asked to rate the overall success of their project on a scale from 0 (min) to 10 (max). Other questions reflected relevant conditions for successful implementation. Principal component analysis showed that several of the items measured with the questionnaire (on a 7-point scale), cluster together into three constructs, resembling the categories described in the introduction: 'organizational support', 'team

organization' and 'external change agent support' (for information on the items see the notes under table 1). Scale reliability, internal item consistency and divergent validity were satisfactory.[14] To measure the number of applied changes, eight activities, relevant for achievement of the project goal, were selected for each QIC from the QIC instruction manuals. Team leaders could mark one out of four options: this is something 1) we do not do, 2) we already did, 3) we intensified/improved since the start of the project, and 4) completely new. For each team the number of applied changes (intensified/improved or new since the project) was counted. The applied change rate ranges from 0 (no change) to 8 (high number of changes).

Each QIC served a particular purpose. The external change agents translated project targets into measurable indicators and teams had to deliver monitoring data to a central database. In this study these monitoring data were used to model the actual success of the teams. An agreement was made with the organization funding the programme (and the independent evaluation the current study is part of) that the data collection burden for participating hospital staff was to be minimized. Therefore the central database was the sole source for team performance indicators. Spreadsheet files with team monitoring data were provided three times by the change agency approximately half a year after the end of the first implementation year (April-June 2006, 2007 and 2008).

For the pressure ulcer teams the prevalence of pressure ulcers was used as an indicator in the analyses. For operation theatre productivity the indicator was the percentage of allocated time actually used and the waiting list indicator was the access time for out-patient appointments in days. The results of these three project types were calculated using the average indicator scores of the first and last two months measured by the teams. There are three sub types among the medication safety projects with their own indicator: the percentage of unnecessary blood transfusions, percentage of unnecessary intravenous antibiotics or percentage of patient with a postoperative pain score exceeding four. The medication safety indicator scores were calculated using the first and last 20 patients treated during the implementation period. Other performance indicators were the change in the prevalence of wound infections. Waiting time before treatment in days was taken as a performance indicator for the process redesign teams. The change in wound infections and process redesign outcomes were computed by comparing the final scores to an identical time period in the past.

The change percentages were converted into a 3-point scale: 1) at least 10% worse than before; 2) neutral; and 3) improved by at least 10%. Compared to goals such as 30%, 40-90% and 50% improvement (table 1.1) 10% improvement seems modest. However, several evaluation reports revealed that even 10% is unrealistic for some teams, making a higher threshold less sensible.[30]

Analyses

Multilevel regression analyses were conducted to answer the research questions. The main argument behind multilevel modelling is that social processes often take place within a layered structure. The assumption that data structures are purely hierarchical, however, is often an over-simplification. Entities such as people or teams may belong to more than one grouping and each grouping can be a source of variation. Each team in the current study belongs to one of the 18 QICs and to one of the 24 programme hospitals. For that reason a cross classified multilevel model is the most accurate model to study the hypothesized relations between conditions, applied changes and outcomes (figure 2).

INSERT FIGURE 2

The variance can be separated into three parts: a part due to differences between teams (level 1), a part due to differences between QICs (level 2) and a part due to differences between hospitals (level 3). In the model the relations of figure 1 were tested in a three-level cross-classified structure as depicted in figure 2. Intercept variances of all variables were estimated at all levels. Co-variances and correlations between the variables were estimated at level 1 to begin with (given the relatively limited sample size) and at higher levels if the variables belonging to one of the relations in figure 1 differed between QICs or hospitals. The intercept variances and co-variances were used to calculate the Variance Partition Coefficient (VPC) i.e. the proportion of variance per variable at each of the three levels. Because correlations are standardized co-variances they may seem redundant. Still, since they range between -1 and 1, they provide an easier interpretation of the strength of a relation between two variables than co-variances.

Besides random effects five fixed effects were included in the model to test the relation between conditions and applied changes (relation d) and between applied changes and outcomes (relation e). All analyses were performed using MLwiN software version 2.02. Estimation method was iterated generalized least squares (IGLS).[31]

Results

A total of 168 team leaders, belonging to 23 hospitals and 18 QICs, filled out the questionnaire (71% response rate). Table 2 contains the averages, ranges and standard deviations of the three factor scores, the applied changes, perceived success and performance indicator. The number of changed activities was known of 95% of the responding teams (n=159), overall grades (perceived success) are available of 82% of the teams (n=137), and 61% of the teams was capable and willing to deliver enough monitoring data to calculate a before and after measurement (performance indicator) (n=103). Indicator data were available of 94% of the operation theatre productivity teams, 82% or the pressure ulcer teams, 78% of the waiting list teams, 50% of the wound infection teams, 41% of the medication safety teams, and 36% of the process redesign teams.

INSERT TABLE 2

Team activities and performance outcomes for each project type

The information presented in table 3 serves as background material. The table provides the number of teams who changed their activities since the project and the average number of applied changes per project type. Pressure ulcer teams mainly applied regular change of patient position (68%) and performed a risk assessment (64%). Medication safety interventions predominantly reflect the three sub topics the teams dealt with: postoperative pain, blood transfusions and intravenous antibiotics (29-38%). Operation theatre teams focused on starting on time (61%). Wound infection teams reduced the number of door movements and the number of individuals in the operation theatre (89%). They also paid attention to a protocol for optimal administering of antibiotic prophylaxis (61%). Process redesign teams reduced the number of planning moments, reserved slots for specific diagnosis (61%),

and clarified decision lines and division of responsibilities (58%). Waiting list teams blocked agendas for six to eight weeks (72%) and anticipated on fluctuations (64%). The average number of applied changes per project type ranged from 2.06 (MS) to 4.4 (WWW).

Besides the average changes in activities, the percentage of teams (with data available) experiencing an improvement on the performance indicator by at least 10% also differs between the six project types. This criterion is met by 70% of the pressure ulcer teams (reduction of pressure ulcers), 100% of the medication safety teams, 12% of the operation theatre teams (use of allocated time), 56% of the wound infections teams, 83% of the process redesign teams (throughput times for diagnostics and treatment), and 46% of the waiting list teams (access time).

INSERT TABLE 3

Statistical modelling

To learn more about the process and outcomes of QIC-implementation a multilevel model was tested, based on expected relations between conditions, applied changes and project outcomes, whilst taking into account the hierarchical data structure. The relations a, b and c are addressed using the correlations and the VPC. In the upper half of table 4 the estimated variances (diagonal), co-variances (above diagonal) and correlations (below diagonal) are presented. The estimates are clustered vertically into three levels: team, QIC and hospital. The upper right column contains the VPC. The VPC percentages of each level add up to 100%.

Relation a. At team level the existence of a positive relation between perceived success and performance indicator score could not be confirmed ($P>0.05$). Perceived successes and performance indicator scores differ significantly between QICs ($P<0.05$). By means of an iterative process, the possibility was explored that the expected type a relation exists at QIC level. A strong positive relation would indicate that it mattered which QIC a team joined, a weak relation would refute this theory. After having estimated the level 2 correlation between both variables, the relation could be confirmed. Table 4 shows that the correlation between perceived success and performance indicator score is maximal at QIC level (Pearson's $r=1.00$; $P<0.05$; VPC level 2: 20% respectively 48%).

Relation b. There is a positive relation between the three conditions. Correlation coefficients range from 0.21 to 0.37 (P<0.01 and P<0.001). A substantial part of the variance in organizational support is located at hospital level. This means that hospitals – apart from differences between types of QIC-projects – differ in the extent to which team leaders are satisfied about the organizational support they receive (P<0.05; VPC level 3: 10%).

Relation c. Relations between organizational support, team organization and overall perceived success are positive and significant, with correlations of 0.29 (P<0.001) respectively 0.30 (P<0.001). The relation between external change agent support and perceived success is not significant (P>0.05), just like the relation between the three conditions and performance indicator (P>0.05).

The relations d and e are addressed using fixed effect estimates. *Relation d.* Testing the association between the conditions and the number of changes in working methods and activities applied by the teams showed that two of the three relations are significant. An increase in the number of applied changes by 1 is accompanied by an increase in organizational support by 0.12 and an increase in external change agent support by 0.19 (P<0.001). Conversely, if organizational support or external support increase by 1, the number of applied changes increases by more than 8 respectively 5. The relation between team organization and the number of applied changes is insignificant.

Relation e. The number of applied changes is confirmed to have a positive effect on perceived success (P<0.001) and indicator outcomes (P<0.05).

Discussion

In this article a model was tested to gain a better understanding of the QIC black box. The study objective was to answer two questions: 1) to what extent do the expected relationships between necessary conditions, applied changes, perceived degree of success and performance indicator outcomes exist; and 2) can differences in conditions and outcomes be explained by the fact that the teams belong to different QICs and hospitals?

Question 1. The opinion of team leaders about organizational and external change agent support is positively related to the number of intensified or new working methods applied. A higher number of changed working methods has a positive influence on the degree of perceived success and

performance indicator outcome. Positive relations between the three conditions, and between perceived success and organizational support and team organization could be confirmed. The relations between performance indicator and conditions, and between performance indicator and perceived success are insignificant (at team level).

Question 2. The multilevel model adds an important dimension that would have been ignored in a single level approach. Judgements on external change agent support and team organization, and performance indicator outcomes do not seem to differ between hospitals, but organizational support does. At QIC level there are differences in perceived success and performance outcomes. Moreover, at QIC level higher judgements are accompanied by higher indicator scores.

Complex relation between perceived success and indicator outcomes

In the introduction it was mentioned that QICs are popular as improvement instruments despite the limited availability of empirical proof supporting their effectiveness. Mittman explained how subjective ratings provided by collaborative participants and leaders are subject to unintentional and unrecognized biases generated by common human decision and judgment heuristics. In that respect he exemplified how a combination of expectation biases and belief perseverance produces systematic overweighting of evidence and observations. A priori expectations and beliefs are confirmed while evidence that does not support the effectiveness of the QIC method is underweighted or discounted.[4] This study confirms the risk addressed by Mittman. The overall judgement of an individual team leader is confirmed to say little about actual indicator outcomes and vice versa. This is not necessarily a bad thing (at least, as long as the evaluation goal is not about assessing cost effectiveness or public accountability of the means invested in QIC programmes). Still, parties involved in implementing QIC projects should be extremely cautious when it comes to rating and explaining the merits of their work, especially when monitoring data were not (yet) available. This also applies for QIC researchers who use perceived successes as proxy variable for actual performance. The overall success judgement apparently represents something different than monitored progress towards project goals. The number of applied changes is related to perceived success. Also, it is likely that team leaders base their success judgement on other accomplishments e.g. they notice how patients benefited from the project or how

the team managed to change old routines and implemented new interventions that are expected to pay off in the long run.

Future research

Researchers are in a situation where many questions remain unanswered. For example about the effectiveness of QICs as improvement and spread strategy.[1] Or why some hospitals are better in supporting project teams than others. Lessons must be formulated to help external change agents with their difficult task to make collaborative projects generic and at the same time sufficiently compatible to unique hospital settings. Research is needed to enable teams to overcome obstacles and optimize QIC- implementation. The advice to adopt hierarchical models in future research should be taken as serious as recommendations for more experimental,[6] narrative,[12] or action based research studies.[32]

Strengths and weaknesses

The multilevel approach is one of the strengths of this study. Other strengths are that the conditions were measured using a validated and reliable instrument, and perceptions were linked to outcome data. The dependence on data provided by the teams is a limitation. Despite the high response rate, the use of self-reported perceptions always involves a risk of overestimation or social desirability. Outcome indicators could be linked to questionnaire data in 61% of all teams in the study sample. It is very likely that positive results are overrepresented, particularly because the absence of monitoring data may very well be caused by the fact that teams were incapable of implementing the project (and the required measurements) as planned. In that sense the performance indicators scores presented in this article do not represent the overall level of success of the programme entirely. Finally, the number of applied changes was modelled without taking into account the influence of individual (key) interventions or specific combinations. In reality, some interventions are more time consuming and complex than others, and some interventions may even not be suited for application within a collaborative.[33]

Conclusion

By examining 18 QICs, part of a quality improvement programme for hospitals, several expected relationships could be verified. Positive relations were found between conditions for successful implementation, between support and the number of changes applied by QIC-teams during the implementation, and between the number of applied changes and the perceived degree of success as well as performance indicator scores. Relations between team organization and the number of applied changes or between the three conditions and performance indicators could not be confirmed. By taking into account the fact that QIC-teams are part of a cross-classified hierarchical data structure it became clear that organizational support differs between hospitals. The hypothesized relation between perceived success and performance indicator does not exist at team level but at QIC level. One should be cautious when accepting perceived successes as a proxy for the actual success of individual teams.

Competing interests

The authors declare that they have no competing interests.

Author's contribution

MLAD was responsible for designing the study, acquiring, analyzing and interpreting the data and drafting the manuscript. PS assisted with the analyses and interpretation of the data. As research manager of the independent evaluation study of the hospital improvement programme CW was responsible for designing the study. CW and PPG assisted in interpreting the results and revising the manuscript for intellectual content. All authors have read and approved the final manuscript.

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Table 1. Breakthrough projects: targets and planned number per hospital in two years

Quality area	Breakthrough project	Programme targets	Number of planned projects per hospital in year one
Patient logistics	WWW: working without waiting lists	– Access time for out-patient appointments	2
	OT: operating theatre	– Increasing the productivity of operating theatres by 30%	1
	PRD: process redesign	– Decreasing the total duration of diagnostics and treatment by 40-90% – Reducing length of in-hospital stay by 30%	2
Patient safety	MS: medication safety	– Decreasing the number of medication errors by 50%	2
	PU: pressure ulcers	– The percentage of pressure ulcers is lower than 5%	2
	POWI: postoperative wound infections	– Decreasing postoperative wound infections by 50%	1
Total			**10**

Box 1. Breakthrough collaboratives within Better Faster pillar 3

During BFp3 multidisciplinary hospital teams implement QIC projects that are to be disseminated further in the next year and afterwards. The projects are based on the IHI Breakthrough series wherein implementation demands repeated application of the Nolan model. Professionals run improvement cycles (plan-do-study-act) and answer three questions: 1) 'what are we trying to accomplish?' 2) 'how will we know that a change is an improvement?' and 3) 'what change can we make that will result in an improvement?'[9] External change agents – change experts and experienced consultants – organize a series of training meetings. The teams are supposed to test interventions, systematically measure their outcomes and compete with other teams.[10] The BFp3 collaboratives have different quality goals divided over two domains: patient logistics and safety (table 1).[11]

Table 2. The means, ranges and standard deviation (SD) of the six variables

Variable name:	N	Mean	Min-Max	SD
External change agent support[1]	168	4.53	1.36-6.91	1.00*
Team organization[2]	168	5.26	2.57-7.13*	1.00*
Organizational support[3]	168	4.57	1.99-6.41	1.00*
Number of applied changes	159	3.46	0.00-8.00	2.04
Perceived success (overall judgement project leader)	137	6.67	1.00-10.00	1.65
Actual success (performance indicator)	103	2.33	1.00-3.00	0.86

* variable is a saved factor score (see items below), therefore estimated factor values can exceed the lower and upper scale ends, standard deviations are equal to 1

[1] Items: at collaborative meetings I always gain valuable insights and external change agents a) provide sufficient support and instruments; b) raised high expectations about performance and improvement potential; c) made clear from the beginning what the goal of the project is, and what the best way is to achieve it; Cronbach's alpha: 0.77.

[2] Items: good communication and coordination, clear division of tasks, everyone is doing what he or she should do, team is responsible and in charge of implementation; Cronbach's alpha: 0.84.

[3] Items: project is important to strategic management, strategic management supports project actively, hospital gives support needed in the department(s) to make the project a success, board does everything in its power to increase the willingness to change and pays attention to the activities of the project team; Cronbach's alpha: 0.91.

Table 3. Activities per Breakthrough project: changes implemented during the project (N = 159)

Intensified or new activities to…	**More actively or new since project No. of teams (%)**
Reduce pressure ulcers (28 teams)	
1. regularly changing patient's position	19 (68%)
2. risk assessment each patient	18 (64%)
3. patient information brochure on pressure ulcers	16 (57%)
4. compliance to a pressure ulcers protocol	13 (46%)
5. updating the pressure ulcers protocol	12 (43%)
6. occupational and physiotherapy	9 (32%)
7. sufficient anti pressure ulcers mattresses	6 (21%)
8. specialized pressure ulcer nurse	4 (14%)
Average number of changes (out of 8) applied by pressure ulcer teams	**3.5**
Improve medication safety (34 teams)	
1. clinical lesson in pain reduction	13 (38%)
2. spreading a simple card with 'switch' guidelines	12 (35%)
3. reducing postoperative pain; pain score on linear scale <4	11 (32%)
4. reduce degree of unnecessary intravenous antibiotics	10 (29%)
5. compliance to a medication prescription and administering protocol	8 (24%)
6. apply guideline to reduce unnecessary blood transfusion	6 (18%)
7. fixed medication times	4 (12%)
8. double check of all medication	2 (6%)
Average number of changes (out of 8) applied by medication safety teams	**2.0**
Optimize operation theatre productivity (18 teams)	
1. starting on time	11 (61%)
2. emergency procedures: (re)definition of 'emergency'	8 (44%)
2. reallocate extra operation time based on the degree of utilization	8 (44%)
4. tracking and solving disturbances in the operation theatre programme	7 (39%)
5. planning based on average surgery time	6 (33%)
5. reduce time between operations	6 (33%)
7. maintaining capacity for emergency available in the programme	5 (28%)
8. staff planning based on differences in surgery time of individual clinicians, differences in anaesthesiologists and assistants, and the experience of the team	2 (11%)
Average number of changes (out of 8) applied by operation theatre teams	**2.9**
Reduce postoperative wound infections (18 teams)	
1. limiting the number of persons in the operation theatre	16 (89%)
1. reducing number of door movements	16 (89%)
3. protocol for optimal administering of antibiotic prophylaxis	11 (61%)
4. participation in national wound infections surveillance network	8 (44%)
5. minimize refreshment of bandages	5 (28%)
6. staff reports (skin) infections and diarrhoea	5 (28%)
7. separate working tablet is used for each patient (bandages, instruments, gloves, deposit bags etc.; afterwards cleansing with alcohol)	4 (22%)
8. during wound care no beds are made, nor the ward is cleaned	2 (11%)
Average number of changes (out of 8) applied by wound infections teams	**3.6**
Reduce throughput times (33 teams)	
1. reserving slots for specific diagnosis	20 (61%)
1. reducing planning moments	20 (61%)
3. clear decision lines and division of responsibilities	19 (58%)
4. rational planning of demand on expected question	18 (55%)
5. introduction one stop shop	16 (48%)
6. admission on day of operation	12 (36%)
6. more flexible staff utilization	12 (36%)
8. protocol for treatment groups (e.g. physiotherapy or informing patients)	11 (33%)
Average number of changes (out of 8) applied by process redesign teams	**3.9**
Reduce waiting list (36 teams)	
1. block agendas six or eight weeks in advance; cancellation only in case of emergency	26 (72%)
2. anticipate on fluctuations	23 (64%)
3. minimize types of consults	21 (58%)
3. plan patient consults not routinely but in case of complaints	21 (58%)
5. perform diagnostics in less consults	20 (56%)
6. minimization of vacations in busy periods	17 (47%)
7. increase the interval for consultations for chronic disorders	17 (47%)
8. realistic planning based on actual consult length	16 (44%)
Average number of changes (out of 8) applied by waiting list teams	**4.4**

Table 4. Predicted relations between six variables: the number of applied changes, three conditions and two outcomes

RANDOM EFECTS*	OS (SE)	TO (SE)	ES (SE)	PS (SE)	PI (SE)	VPC** (%)
Team (level 1)						
Organizational support (OS)	**0.69 (0.08)**[c]	0.29 (0.07)[c]	0.18 (0.06)[b]	0.36 (0.11)[b]	-0.12 (0.07)	1.40 (90%)
Team organization (TO)	*0.37*[c]	**0.86 (0.11)**[c]	0.17 (0.07)[a]	0.38 (0.13)[b]	0.10 (0.08)	1.80 (93%)
External support (ES)	*0.25*[b]	*0.21*[a]	**0.75 (0.08)**[c]	0.10 (0.12)	-0.04 (0.08)	1.16 (91%)
Perceived success (PS)	*0.30*[b]	*0.29*[b]	*0.08*	**2.01 (0.29)**[c]	-0.09 (0.13)	2.76 (79%)
Performance indicator (PI)	*-0.19*	*0.14*	*-0.05*	*-0.08*	**0.62 (0.11)**[c]	0.47 (52%)
QIC (level 2)						
Organizational support (OS)	**0.00 (0.00)**	-	-	-	-	0.00 (0%)
Team organization (TO)	-	**0.07 (0.06)**	-	-	-	0.07 (4%)
External support (ES)	-	-	**0.03 (0.04)**	-	-	0.03 (2%)
Perceived success (PS)	-	-	-	**0.42 (0.23)**[a]	0.29 (0.13)[a]	0.71 (20%)
Performance indicator (PI)	-	-	-	*1.00*	**0.15 (0.09)**[a]	0.44 (48%)
Hospital (level 3)						
Organizational support (OS)	**0.15 (0.07)**[a]	-	-	-	-	0.15 (10%)
Team organization (TO)	-	**0.06 (0.05)**	-	-	-	0.06 (3%)
External support (ES)	-	-	**0.08 (0.06)**	-	-	0.08 (6%)
Perceived success (PS)	-	-	-	**0.04 (0.12)**	-	0.04 (1%)
Performance indicator (PI)					**0.00 (0.05)**	0.00 (0%)
FIXED EFFECTS						
(Intercept)	-0.45 (0.16)[b]	-0.11 (0.18)	-0.69 (0.17)[c]	5.57 (0.31)[c]	2.03 (0.21)[c]	
Applied changes	0.12 (0.04)[c]	0.04 (0.04)	0.19 (0.04)[c]	0.31 (0.07)[c]	0.09 (0.05)[a]	

* Intercept variances diagonal, co-variances above diagonal and correlations (in grey italic) below diagonal

** The variance partition coefficient (VPC) represents the proportion of variance (the sum of intercept variance and co-variances) of each variable per level (the variance at all three levels adds up to 100%)

[a] P<0.05 [b] P<0.01 [c] P<0.001

Figure 1

Figure 1. Study model: hypothesized positive relations between conditions, applied changes and outcome measures

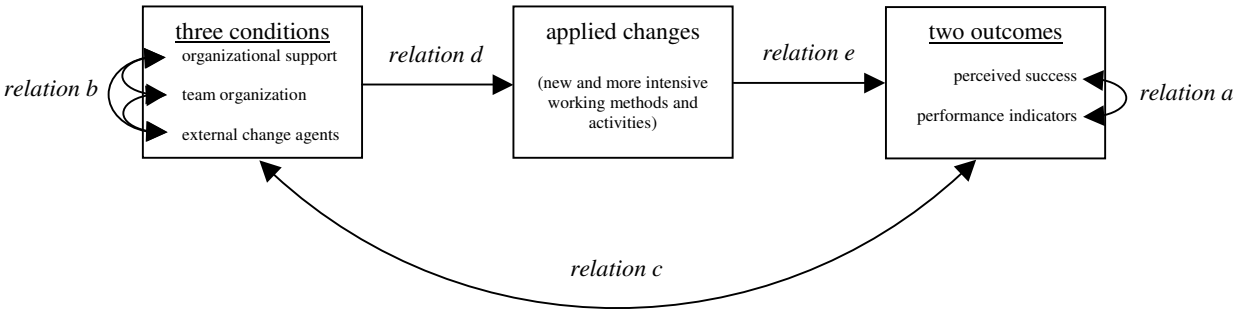

Figure 2. Cross-classified data structure: project teams nested in QICs and hospitals

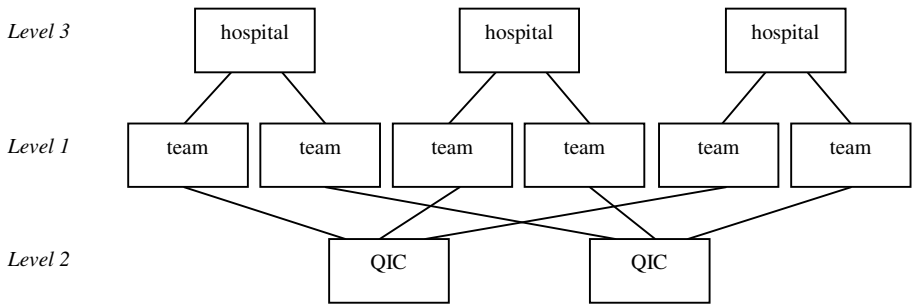

Figure 2