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Multidisciplinary simulation-based team training for surgical teams: protocol for a stepped-wedge cluster mixed methods evaluation of a national, insurer-funded initiative

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Title

Multidisciplinary simulation-based team training for surgical teams: protocol for a stepped-wedge cluster mixed methods evaluation of a national, insurer-funded initiative.

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Author contributions

The study protocol was conceived by JW and AM. All authors contributed to the development of the protocol and the manuscript. JW prepared the final manuscript. All authors approved the final version of the manuscript.
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Abstract

Introduction

NetworkZ is a national, insurer-funded multidisciplinary simulation-based team-training programme for all New Zealand surgical. NetworkZ is delivered in situ, utilising full-body commercial simulators integrated with bespoke surgical models. Rolled out nationally over four years, the program builds local capacity through instructor training and provision of simulation resources. We aim to improve surgical patient outcomes by improving teamwork through regular simulation-based multidisciplinary training in all New Zealand hospitals.

Methods and analysis

Our primary hypothesis is that surgical patient outcomes will improve following NetworkZ. Our secondary hypotheses are that teamwork processes will improve, and treatment injury claims will decline. In addition, we will explore factors that influence implementation and sustainability of NetworkZ and identify organisational changes following its introduction.

The study utilises a stepped-wedge cluster design. The intervention will roll out at yearly intervals to four cohorts of five District Health Boards (DHB). The primary outcome measure is Days Alive and Out of Hospital at 90 days using patient data from an existing national administrative database.

Secondary outcomes measures will include analysis of post-operative complications and treatment injury claims, surveys of teamwork and safety culture, in-theatre observations, and stakeholder interviews.

Ethics and dissemination

We believe this is the first surgical team training intervention to be implemented on a national scale, and a unique opportunity to evaluate a
nation-wide team-training intervention for healthcare teams. By using a pre-existing large administrative data set, we have the potential to demonstrate a difference to surgical patient outcomes. This will be of interest to those working in the field of healthcare teamwork, quality improvement and patient safety. New Zealand Health and Disability Ethic Committee approval (#16/NTB/143). Australian and New Zealand Clinical Trials Registry ID ACTRN12617000017325.

**Article summary**

**Strengths and limitations of this study**

1. The study uses a mixed methods approach to test the effectiveness of the NetworkZ training intervention in the context of real-world implementation across an entire nation.

2. Our primary outcomes measure, Days Alive and Out of Hospital at 90 Days, is an holistic measure of surgical outcomes utilising routinely collected health data from a national administrative database.

3. Programme rollout follows a stepped wedge cluster-randomised design in which cohorts of sites move progressively from baseline to post-implementation states in random order.

4. Running the training programmes is subject to willingness of hospitals to participate, and their own constraints around dates and numbers of courses. This could compromise the purity of the stepped wedge design.

5. Possible confounding by another factor operating progressively over time is a limitation of our design

**Keywords**

Surgery; patient safety; simulation; multidisciplinary; teamwork; protocol.
Background

Unintended harm to patients due to medical treatment is a major contributor to the global burden of disease.(1) In a systematic review of studies assessing inpatient outcomes(2) surgical procedures were associated with 39.6% of all adverse events and were commonly associated with unintended injury during hospitalisation. Communication failures contribute to many medical mishaps(3) and sentinel events. In one study communication failures affected about 30% of team interactions in the operating theatre(4), and in another they contributed to 43% of surgical errors.(5) Even when operating theatre staff work hard to maintain good relationships and minimise tensions,(6) disciplinary silos(7) professional rivalries(8) and hierarchy(3) create barriers to effective communication.

The Agency for Healthcare Research and Quality recommends team training as a patient safety strategy.(9) Team training is effective in improving communication.(10, 11) There is moderate to high-quality evidence that it can improve team processes, clinical processes, and patient outcomes.(12, 13) Team training can improve safety culture and encourage attitudes and behaviours commonly found in high reliability organisations.(14) Simulation is frequently used in successful team training initiatives. This study protocol focuses on the evaluation of a national simulation-based team training initiative.(15, 16)

Healthcare for New Zealand’s population of 4.8 million people is provided through 20 District Health Boards (DHBs) of varying size, with the smallest servicing a population of around 32,000, and the largest servicing a population to over 600,000. Each DHB includes one or more publicly funded hospital. New Zealand has a national no-fault insurer, the Accident Compensation Corporation.
(ACC), which compensates accident victims who sustain injuries, including injuries following treatment (known as "treatment injuries"). The number and costs of treatment injuries has increased over the last 5 years. In 2015/16 ACC accepted 8,881 medical and surgical treatment injury claims, with incurred costs of NZ$418 million. In an effort to reduce the human and fiscal toll of these events ACC is investing NZ$45 million over a five-year period into initiatives to reduce treatment injuries, targeting surgery, surgical site infections, pressure injuries, and maternity care.(17) Ten million dollars of that investment is funding a multidisciplinary, simulation-based team training programme, NetworkZ.

The NetworkZ programme is run in situ in operating theatres with full surgical teams who normally work together, to be implemented in all public hospitals in New Zealand. It is supported by the NetworkZ Instructor course, which trains DHB staff to deliver the programme in their DHB. A full description of the programme can be found at www.networkz.ac.nz and in Supplementary Material 1.

In a pilot study, 20 surgical teams from two large Auckland hospitals participated in NetworkZ at the University of Auckland (UOA) Simulation Centre for Patient Safety with positive participant evaluations and improved scores for observed teamwork.(18-21) The national roll-out now offers an opportunity to test the impact of team training on surgical outcomes at a national level.

We propose that, for a team-training programme to have a widespread and lasting impact on teamwork and communication, it must meet a number of conditions. It should involve teams that normally work together, and take place in the workplace, and in their own environment. It should be developed and delivered by a multidisciplinary team. It should have a sound theoretical
framework for teamwork, educational approach and implementation. It should be locally 'owned' and led (as opposed to being externally imposed) following the initial implementation phase and the training should be provided in a 'sufficient dose' to involve the majority of staff in the training.

The educational framework for NetworkZ draws on the work of Kolb(22) and Boud(23) on experiential learning and reflective practice, and embraces interprofessional learning, gaining insights into the beliefs and roles of others, challenging assumptions, and strengthening social bonds between group members. It draws upon an evidence-based model of the features of effective teams teamwork conceptualised by Salas and colleagues.(24) The key features of this model are leadership, adaptability, mutual performance monitoring, back-up behaviour and team orientation. The underpinning elements are a shared mental model, clear concise communication and mutual trust and respect.

Our implementation strategy builds on the work of Bate,(25) and Dixon-Woods.(26) Factors believed to foster successful implementation of initiatives such as ours include organisational support and a shared commitment to the programme, leadership engagement, staff empowerment and networking, engaging clinical champions, together with building intrinsic staff motivation.(25, 27) Hence implementation of the NetworkZ programme will provide extensive initial support, senior management engagement and resourcing and follow a train-the-trainers model for local embedding and long-term sustainability. The implementation strategy is described in more detail in Supplementary Material 1.

The aim of NetworkZ is to improve outcomes for surgical patients by improving teamwork and communication in operating theatre teams through embedding
regular simulation-based multidisciplinary team training in New Zealand hospitals.

**Methods**
In this study we will address the following hypotheses and research questions.

**Primary Hypothesis**
Our primary hypothesis is that surgical patient outcomes will be improved following the implementation of NetworkZ as manifested in days alive and out of hospital over 90 days (DAOH\(_{90}\)).

**Secondary hypotheses**
Our two secondary hypotheses are: (1) teamwork and communication processes will be improved and (2) the number and cost of ACC treatment injury claims will decline following the introduction of our training programme.

**Qualitative research questions**
We aim to: explore the factors that facilitate or impede implementation of NetworkZ; understand requirements for long-term sustainability; and identify the types of changes occurring in the workplace following the implementation of NetworkZ.

**Study population**
There are two distinct populations included in the study protocol: the population of surgical patients and the population of surgical staff.

**Patient population.**
We will include patients undergoing surgery in public hospitals in New Zealand between February 1\(^{st}\) 2016 and April 30\(^{th}\) 2022 for patient outcome measures. We will obtain outcome data for our primary hypothesis from the National
Minimum Dataset (NMDS), a reliable administrative dataset collected by the New Zealand Ministry of Health. This data set provides a confidential and comprehensive record of all public hospital admissions and discharges in New Zealand, including demographics, ICD diagnoses, procedures, length of stay, and mortality associated with each admission. In 2017 the NMDS included 330,353 cases of publicly funded surgery.\(^{(28)}\) The funding for NetworkZ allowed us to provide the team training for five major surgical specialities: general, orthopaedics, urology, otorhinolaryngology and plastics.

For inclusion and exclusion criteria see Table 1.

Table 1. Inclusion and exclusion criteria for patients and hospital staff.

<table>
<thead>
<tr>
<th>Study inclusion criteria</th>
<th>Study exclusion criteria</th>
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<tr>
<td><strong>Surgical patient admissions</strong></td>
<td><strong>Patient admissions that meet any of the following criteria:</strong></td>
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<tr>
<td>Patient admissions that meet all of the following criteria:</td>
<td>- admitted and discharged on the day of surgery</td>
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<tr>
<td>- receive surgery in the five targeted surgical specialties</td>
<td>- admitted to private hospitals</td>
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<tr>
<td>- receive surgical intervention involving a full surgical team</td>
<td>- receiving endoscopy using operator supervised sedation</td>
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<tr>
<td>- requiring an overnight stay</td>
<td>- procedures requiring local infiltration only</td>
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<td>- receive regional or general anaesthesia</td>
<td>- patients admitted to stand-alone paediatric hospitals.</td>
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<tr>
<td>- admitted for surgery to a publically funded hospital that has been, or will be, involved in the NetworkZ programme.</td>
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<tr>
<td>All subsequent readmissions to any hospital facility within the following 90 days will also be included.</td>
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<tr>
<th><strong>Hospital staff</strong></th>
<th><strong>Hospital staff working as:</strong></th>
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<tr>
<td>Public hospital staff working in one of the following roles:</td>
<td>- trainees in surgery or anaesthesia</td>
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<tr>
<td>- surgical specialists in the included five speciality groups</td>
<td>- solely specialised paediatric hospital employees</td>
</tr>
<tr>
<td>- anaesthetic specialists</td>
<td>- house surgeons (junior doctors not in specialist training programmes)</td>
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<tr>
<td>- nursing staff working in operating theatres</td>
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- anaesthetic assistants
  (referred to as Anaesthetic Technicians in New Zealand)
- health care assistants
- solely private hospital employees.

Patient sample size and power analysis

The sample will be all patients undergoing surgery in public hospitals during the study period who stay at least one night in hospital and are undergoing procedures in the included speciality groups. This number has been estimated from the NMDS to be in the order of 500,000 cases over the six-year study period.

Our sample size is primarily pragmatic. Both our design (i.e. stepped-wedge) and primary outcome variable (i.e. DAOH) present significant obstacles to conventional sample size calculations. Nonetheless, we have undertaken an empirical power analysis on simulated data. We generated smooth sampling distributions from historical data for each site. We also generated versions of each distribution with a difference imposed at given quantiles by either flattening or accentuating the peaks in the data (i.e. a larger late peak means more patients with better DAOH). Using the recruitment parameters of our study, we generated 1,000 synthetic datasets with a simulated intervention effect. We compared the control and intervention groups using the Wilcoxon-Mann-Whitney U test, and assessed the significance of the calculated statistic by randomly permuting sites between cohorts 1,000 times, as in Thompson, Davey (29). Our simulations indicate a greater than 99% power at \( \alpha=0.05 \) to detect an intervention effect of one or more DAOH at the median, and two or more DAOH at the 0.25 quantile. We may apply quantile regression risk-
adjustment to statistically evaluate differences of less than one DAOH (i.e. the minimum resolution of unadjusted DAOH data).

Operating theatre staff population

NetworkZ aims to train the majority of eligible staff working in the operating theatres of New Zealand public hospitals. Because there are four Cohorts with a staged annual roll out from 2017 to 2020 inclusive, the expected proportion of eligible operating theatre staff attending training over the study period are: 100% of Cohort 1; 75% of Cohort 2; 50% of Cohort 3; 25% of Cohort 4, and this is the basis of our sample size estimate. For surveys the unit of analysis will be the individual, while for observations, the unit of analysis will be the theatre team. See Table 1 for inclusion and exclusion criteria.

Total surgical staff population size

From specialist registration boards and hospital staffing lists we estimate the following: specialist surgeons ~730; specialist anaesthetists ~750; operating theatre nurses ~1800; anaesthetic technicians ~480. (Total = ~ 3,800 staff)

Operating theatre staff sample size estimate

For surveys, we will include all staff will meeting the inclusion criteria. We will rate between 5 and 10 cases in each DHB in the three-month period prior to the introduction of NetworkZ in that DHB and immediately following the transition period in that DHB. Over the course of the study this will generate between 100 and 200 in the pre-NetworkZ period and a similar number in the post-NetworkZ period. Previous work indicates that fewer than 20 cases before and 20 after an intervention can detect a difference of one point on the seven point WHOBARS scale(30) in 80% of cases. We are undertaking more observations to obtain a representative sample across DHBs.
**Trial design**

This is a mixed methods study, utilising quantitative and qualitative data in a stepped wedge, cluster randomised quality improvement design (see Figure 1). There are four clusters (Cohorts 1-4) of five DHBs each with the order of participation of Cohorts 2-4 selected randomly. Randomisation process: Each of the 20 DHBs was allocated a number written on a card. The DHBs were then divided into five groups of similar size, calculated from publicly available Ministry of Health data on population sized served by each DHB. The first cohort comprised one DHB purposively selected from each of these five groups on the basis of perceived interest and readiness to participate. Following this initial selection, a card from each group was then blindly selected for Cohort 2 and then for Cohort 3. The remaining cards comprised Cohort 4.

Comparison of outcomes will be undertaken between the pre-intervention period (control) starting one year before the first NetworkZ course in Cohort 1 DHBs, and the post-intervention period ending one year after the end of the transition period in Cohort 4. The transition period runs from the start of the DHB training for a Cohort, and lasts for 15 months, during which at least one third of staff in that Cohort should have attended a course. We believe that the effects from the intervention will not clearly manifest until at least 15 months, by which time a significant proportion of the staff will be trained and experienced with the intervention. No quantitative data will be collected during the transition period. We have chosen the stepped wedge cluster design because it lends itself to a staged quality improvement project in which individual participants cannot be randomised to intervention or control. (31) (see Figure 1)

*[Figure 1 about here]*
Outcome measures

Primary outcome measure (addressing primary hypothesis)

The primary outcome measure for the study is Days Alive and out of Hospital after 90 days (DAOH$_{90}$), recently validated by Jerath, Austin (32).

DAOH provides a holistic approach to measuring patient harm that incorporates mortality and length of time out of hospital for a defined number of days (in this case 90 days) following an index event (in this case, a surgical procedure).(33) Days in hospital include those until discharge following surgery, and those during any readmissions to public hospitals within the specified 90-day postoperative period. DAOH$_{90}$ scores will be affected by mortality and any complications that either prolong hospitalisation or result in readmission.

DAOH$_{90}$ score will be zero for patients who die without ever leaving hospital, but any day alive and out of hospital during the 90-day period will be counted.

Index procedures for DAOH$_{90}$ will be limited to patients who stay in hospital for at least one night. The rationale for this is to restrict the patient population to those at higher risk of adverse events, and to increase the likelihood that when a patient is admitted for a diagnostic procedure prior to definitive surgery, the 90-day period begins with this definitive surgery. A surgical admission within 90 days will be subtracted from the 90 days when calculating DAOH$_{90}$. The analysis will adjust for time (month and year of procedure), cohort, DHB (within cohort) and intervention, with the primary comparison using the cohort as the replicate of the intervention effects. Additionally, we will explore the influence of the proportion of staff in each DHB who have attended a NetworkZ course. In a secondary analysis we will also calculate Days out of Hospital and Mortality separately to tease out the individual effects of these on the primary outcome.
The analysis will follow the procedure for the analysis of the primary outcome measure.

**Statistical analysis**

Using the Stepped Wedge cluster design we will analyse the differences between pre- and post-NetworkZ cohorts on each of the patient outcome measures. Data will be classified into pre-NetworkZ (control), transition, and post-intervention intervention categories (see Figure 1).

We will use a non-parametric Mann Whitney rank sum tests as our primary test for an overall difference between distributions of DAOH\textsubscript{90} before and after implementation of NetworkZ, specifying p <0.05 as significant. We will then perform quantile regression at the 0.1, 0.25, 0.75, 0.9 quantile to characterize any difference between the two distributions. This quantile regression will include time (month and year of procedure), cohort, DHB (within cohort) and intervention as factors in the model.

**Secondary outcome measures (addressing secondary hypotheses)**

**Teamwork Perceptions Survey**

The Teamwork Perceptions Survey was designed to align with the intended learning outcomes of NetworkZ (Supplementary material 2). Items were drawn from behaviours of effective teams described by Salas(24) and refined through review and consensus with an expert group. The survey will be administered to all operating theatre staff who are regularly working in operating theatres in the specialities targeted by the course.

This survey will be administered in the 3-month period prior to a DHB commencing training and repeated at the end of the transition period (at 15
months). Staff in DHBs around the country will be assigned unique confidential identifiers. These identifiers will be used in the surveys to enable matching of participants' pre- and post- intervention survey responses and determine if they have participated in NetworkZ.

**Analysis**

Pre- and post-Teamwork Perceptions Survey total scores and subscale scores will be assessed using a Generalized Linear Mixed Model (GLMM). The analysis will include terms for cohort, DHB (within cohort) and intervention, with the primary comparison using the cohort as the replicate of the intervention effects. Additionally, we will explore the influence of the proportion of staff in each DHB who have been trained.

**Surgical Safety Culture Survey (SSCS)**

The SSCS measures attitudes and behaviours relevant to surgical safety (34) and survey scores have been shown to predict 30-day risk of post-operative death.(35) The Health Quality and Safety Commission (HQSC) has made minor changes to the survey terminology for the New Zealand context. HQSC administers this national survey to all operating theatre staff by on a bi-annual basis. The survey is anonymous but includes demographics such as DHB and professional role. HQSC administered the survey in February 2017 with subsequent administrations planned for February 2019 and February 2021.

**Analysis**

Pre- and post-SCSS total scores and subscale scores will be assessed using a GLMM. The analysis will include terms for cohort, DHB (within cohort) and intervention, with the primary comparison using the cohort as the replicate of the intervention effects.
Observations of WHO Surgical Safety Checklist administration

We will utilise the World Health Organisation Behaviourally Anchored Rating Scale (WHOBARS) observation tool previously developed by members of our research group(30, 36) (see Supplementary material 3). WHOBARS measures the quality of administration of the Surgical Safety Checklist (SSC). The SSC is used almost universally in New Zealand and provides a standardised opportunity to share important information with other members of the surgical team. Changes in teamwork and communication should be reflected in this measure. Case selection for the WHOBARS observations will be a convenience sample of available cases over a 3-day rating period in each DHB and will include any surgical case that falls within the eligibility criteria for NetworkZ. We will record unique staff identifiers for each team observed to enable post-NetworkZ influence of the number and role of staff in a team who have participated in a NetworkZ course. In order to generate reliable scores we will train raters using a series of videos and actual theatre cases.

Analysis

The analysis will compare mean and subscale WHOBARS scores for surgical teams pre- and post- the NetworkZ intervention using a GLMM. The analysis will include terms for cohort, DHB (within cohort) and intervention, with the primary comparison using the cohort as the replicate of the intervention effects. We will also undertake an exploratory analysis to investigate if the proportion of staff trained moderates the difference between pre- and post-training.

Number and costs of ACC treatment injury claims

To provide an indication of the fiscal outcomes of the intervention, surgical treatment injury claims submitted to ACC will be analysed using claims that are relevant to the surgical specialties targeted by NetworkZ. We will exclude
claims that relate to specialties not included in NetworkZ. We will analyse ACC
data using the same patient population groups over the same time-periods as
established for the stepped wedge design for the primary analysis. The analysis
will compare claim data pre- and post- the NetworkZ implementation using a
GLMM. The analysis will include terms for cohort, DHB (within cohort) and
intervention, with the primary comparison using the cohort as the replicate of
the NetworkZ effects. We will conduct separate analyses for the number and
cost of claims.

Qualitative measures (addressing qualitative research questions)
We will undertake interviews with each Cohort to address the three qualitative
research questions. We will conduct semi-structured interviews with DHB staff
involved in NetworkZ on the project team or as instructors. We will identify
potential participants through the NetworkZ database and sampling will be
purposive to include a range of views from large and small DHBs, from different
professional groups, and those with different roles. Sampling will continue to
the point of data sufficiency, when no new themes are emerging and existing
themes are sufficiently described. We anticipate a sample size of 20-30
interviews per Cohort. Timing of interviews will be during the transition period,
during the period of implementation of NetworkZ. Interviews will be
transcribed and coded using NVivo prior to general thematic analysis.

Patient and public involvement
There was no patient or public involvement in the development of this study
protocol.

Ethics and dissemination
This study has been approved by the New Zealand Health and Disability Ethic Committee (HDEC) (#16/NTB/143). The protocol was registered with the Australian and New Zealand Clinical Trials Registry (ANZCTR) on 5th January 2017 and last updated on 7 August 2018. The protocol title is “Evaluation of NetworkZ: Can multidisciplinary team-training improve the safety of surgery in New Zealand?” The Trial ID is ACTRN12617000017325 and the Universal Trial Number is U1111-1189-3992.

Discussion
NetworkZ is a nationwide response to the global need to improve the safety of surgical care. To our knowledge this will be the first occasion when a surgical team training initiative has been implemented on a national scale. Access to routinely collected health data at a national scale is key to the feasibility of our evaluation.

The unique features of NetworkZ team training include: interactive surgical models integrated with computerised full-body computerised manikins that allow all members of the surgical team to participate; in situ training using real teams in real operating theatres; providing simulation resources and instructor training to build local capacity to independently run the course.

Strengths of the study
This is a national study, involving multiple sites and big numbers. It is adequately powered to show a difference if there is one. Access to high-quality national routinely-collected hospital events data is a major strength, without which the study would not be feasible.
Our primary outcome measure, DAOH, is a relatively new measure for surgical patient outcomes, recently validated by Jerath, Austin (32). DAOH$_{90}$, provides a holistic evaluation of surgical outcomes that is sensitive to any cause of death, prolonged hospital stay or readmission. This measure can be reliably and cost-effectively derived from the data in the NMDS and is objective.

Stepped wedge cluster design is very suitable for quality improvement initiatives in which it is impossible (or at least highly impracticable) to randomise individual cases or participants. (31, 37) It is uniquely suited to initiatives that are rolled out over time. It provides a basis for taking account of concurrent changes in the healthcare environment over time that could influence our primary outcome measure.

Another strength of our study is the mixed methods approach. The secondary outcome measures and qualitative data can provide supporting evidence of change attributed to NetworkZ and provide complementary insights into whether the programme is working and why the programme is or is not working.

**Weaknesses of the study**

Team training interventions may take time to have an effect and we may thus fail to detect an effect due to sampling too early. Due to the limited timeframe for implementation of training in the initial Cohort as dictated by our funding contract, Cohort 1 DHBs were not selected randomly, but were purposively selected as we had an existing relationship with those DHBs. There are anticipated limitations of exploring the effect of quality improvement initiatives in the real world, including implications for standardisation, randomisation and control groups. For example implementation of training depends on the
willingness of DHBs to support NetworkZ, local staff to undertake the Instructor Training, and DHB staff to attend the courses.

Despite numerous measures to achieve consistent, high quality training, there are challenges in achieving standardisation of NetworkZ delivery in individual DHBs where the local staff take on the responsibility for implementing the program in their own environments.

Due to the potential for other factors progressively influencing patient outcomes over time, we will not be able to prove that the changes can be attributed to NetworkZ. This will be mitigated to some extent through the stepped wedge design and triangulation with measures of teamwork through surveys and observations.

**Conclusion**

With the financial support of our publicly funded Accident Compensation Corporation, the unique opportunity exists to implement and evaluate a nationwide team-training initiative for full operating theatre teams in all public hospitals in New Zealand. By using a pre-existing large administrative data set, we have the potential to demonstrate a difference to surgical patient outcomes from this quality improvement team-training initiative.

**Acknowledgements**

The authors would like to express special gratitude to Kaylene Henderson, Jane Torrie, Richard Hamblin and Ian Civil for their tireless efforts in the
development and delivery of the NetworkZ programme, and the ongoing support of its evaluation.

**Data statement**

At the conclusion of the study de-identified Teamwork Perceptions Survey data will be available on reasonable request from cmhseadmin@auckland.ac.nz, for a period of five years for academic purposes. Other data that will be utilised in this study either cannot be adequately de-identified or was obtained from third-party databases that the authors do not have authority to grant access to.

**Conflict of interest statement**

Dr. Merry is Chair of the Health Quality and Safety Commission NZ and a director of SaferSleep LLC. Both Dr Merry and Dr Webster hold shares in SaferSleep LLC.

**Funding**

This delivery and evaluation of NetworkZ is funded by the Accident Compensation Corporation of New Zealand, and supported by grants from the Australian and New Zealand College of Anaesthetists (2017 Douglas Joseph Professorship Grant, Project Number DJ17/001), and the Lottery Health Research Fund (Project Number: R-LHR-2017-49141).

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References


Figure 1: The stepped-wedge cluster cohort design

--- Measurement begins 1 February 2016 ---

<table>
<thead>
<tr>
<th>Cohort 1</th>
<th>Begins Feb. 2017</th>
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<tbody>
<tr>
<td>Cohort 2</td>
<td>Begins Feb. 2018</td>
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<td>Cohort 3</td>
<td>Begins Feb. 2019</td>
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<td>Cohort 4</td>
<td>Begins Feb. 2020</td>
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--- Measurement ends 30 April 2022 ---

Key:
- Pre-NetworkZ (Control) period
- Transition period (15 months)
- Post-NetworkZ period
Supplementary material 1

The NetworkZ programme and implementation process

The NetworkZ course

The NetworkZ course full-day course comprising simulated scenarios, debriefs, presentations and group discussion the full-day NetworkZ course can be delivered as two half-day courses in order to minimise operational disruption and thus maximise acceptability. The long-term aim is for all operating theatre staff in New Zealand public hospitals to complete a full day of training at least every three years. The course is designed for the five surgical specialties with the largest number of surgeons: general, orthopaedics, otorhinolaryngology, urology and plastics. Obstetrics and gynaecology for which a simulation training programme (non-OR) already existed was not included.

Scenarios:

When implementation has been completed 25 simulated scenarios will have been developed from actual cases of co-morbid patients presenting for surgery with a range of conditions such as trauma, sepsis, abdominal and post-operative airway emergencies. Simulated scenarios last between 25 and 45 minutes and the scenarios are designed to be challenging and complex with multiple decision points for the entire team. Scenarios begin prior to induction of anaesthesia and include detailed case notes, supporting documentation, imaging and investigations. They take place in each team’s actual operating theatre using available anaesthetic and surgical equipment, drugs and fluids and other consumable items, with formalised strategies to manage known risks of in-situ simulation.(37)

The simulations use the Laerdal 3G SimMan manikins (38) with moulage and custom built face masks and body suits, combined with surgical models to maximise fidelity, to convey different simulated patients and to provide appropriate surgical, anaesthetic and nursing tasks. Examples of the surgical models include a ruptured appendix, a traumatic leg amputation and, and a neck haematoma compromising the airway. The models permit surgical interventions including incision, haemorrhage...
control, suturing, resection, and anastomosis. The manikin is pre-programmed to convey patient status at various phases of the scenario with supervisory control to respond to unexpected participant actions. A full surgical team participates in each scenario including at least one specialist surgeon and one specialist anaesthetist, three theatre nurses and an anaesthetic assistant. Surgical and anaesthesia trainees often participate as do health care assistants and post-anaesthetic care unit nurses.

NetworkZ faculty observe from behind a partition, screen or via video-link (depending on local facilities). Faculty control the manikin and surgical models in response to participant actions and answer participant phone calls for assistance or advice following scripts which replicate local processes. The scenarios are not recorded and there are no participant observers.

Participants are supported by a ‘confederate’ nurse or anaesthetic assistant who is in communication with the instructional team. The confederate assists with clinical tasks in the simulated environment such as taking blood samples or by discreet communication of physical signs unable to be replicated by the manikin or models (e.g. deviated trachea).

Debriefing:

The scenario is followed by a facilitated debrief with 2 trained NetworkZ instructors using three distinct phases: Phase 1 participant reactions; Phase 2 description, analysis, application; Phase 3 personal transfer to practice. Questioning approaches emphasise open questions and advocacy enquiry.(39, 40) Debriefers refer to specific communication tools and teamwork behaviours from the Salas model(24) with the aid of wall-mounted posters. Systems issues identified in the debrief are recorded and reported back to the local quality improvement leader for follow up.

Interactive Presentations:

Purpose-designed trigger videos and animations are used to emphasise communication strategies and specific tools for briefing the team. The strategies and tools include ISBAR, closed loop communication, speaking up, and structured recapping. Participants are encouraged to explore their
different professional roles, perspectives and assumptions to develop strategies to work together more effectively.

**NetworkZ instructor training**

The NetworkZ course quality is assured by the requirement for instructors to demonstrate competency in ten domains of practice, using Entrustable Professional Activities (EPAs) as an organising framework for the curriculum. These domains are: fundamentals of effective teamwork; creating a safe learning environment; conducting a scenario; identifying learning points while observing a scenario; conducting a debrief; evaluating learning; managing risk with in situ simulation; preparing the clinical environment for simulation, operating the simulation equipment; and maintaining simulation resources.

The EPAs are mastered using a blended approach to course delivery that includes face-to-face workshops, online learning and apprentice-ship style learning with observation and feedback from senior faculty. Instructor assessment includes online submissions and assessment of performance.

**Implementation strategy**

Our approach to implementation is multifaceted, incorporating multiple stakeholders; national bodies included central committees of the 20 New Zealand District Health Board (DHB) executives, the Royal Australasian College of Surgeons, the Australian and New Zealand College of Anaesthetists; New Zealand Nursing Council; and Institute of Anaesthetic Technicians. Approximately 12 months prior to the introduction of NetworkZ, the NetworkZ project team meet the DHB senior executive team, and negotiate a formal letter of agreement with the Chief Executive. This outlines the gift of a 3G Laerdal simulator and some surgical models to the DHB, provision of training and support by the NetworkZ project team and the expectations of DHB support for release of staff to attend training with provision of the training venue. In each DHB local project teams are established with connections to senior executive and quality assurance leads. A local group of instructors are nominated and undertake training. NetworkZ training in the DHB is initially supported by UOA faculty but gradually devolved
to local DHB instructors as they complete NetworkZ instructor training. After 12 to 15 months, DHBs assume full responsibility for running the NetworkZ course in their DHB. UOA maintains a role in quality improvement, instructor training and course development.
Teamwork Perceptions Survey

Please rate the following components of teamwork in the operating theatre teams where you regularly work. We acknowledge that your experiences will vary between different theatre teams. Please try to give an average rating for your experiences of teamwork across the theatres where you regularly work, rather than rating one specific theatre team.

Please note this is about the whole theatre team, including surgeons, nurses, techs and anaesthetists.

SA = Strongly Agree; A=Agree; N=Neutral; D=Disagree; SD=Strongly Disagree

<table>
<thead>
<tr>
<th>In general, in theatres where I regularly work, senior staff (e.g. consultant surgeon and anaesthetist, senior nurse, charge tech):</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
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<tr>
<td>1. Provide clear directions to the team</td>
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<td>2. Use an appropriate balance of assertiveness and support</td>
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<td>3. Motivate team members to do their best</td>
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<td>4. Establish a positive atmosphere in theatre</td>
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<td>5. Facilitate team problem solving during the case</td>
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<td>6. Role model acceptable interaction with colleagues</td>
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<td>7. Engage in pre case briefings of the whole team</td>
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<td>8. Co-ordinate tasks and individual team member contributions to patient care</td>
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<th>Team members:</th>
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<td>9. Provide support to each other</td>
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<td>10. Shift work responsibilities to underutilised team members at times of high workload</td>
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<td>11. Keep an eye on other team members’ performance</td>
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<td>12. Speak up about potential mistakes or lapses in other team members’ plans or actions</td>
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<td>13. Provide constructive feedback regarding team member actions to facilitate self-correction</td>
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<td>14. Are willing to acknowledge mistakes and accept feedback</td>
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<td>15. Value the input of all team members to patient care</td>
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<td>16. Take into account alternative solutions offered by other team members</td>
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<td>17.</td>
<td>Share information about the case planning, progress and concerns with other team members</td>
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<td>18.</td>
<td>Involve the whole team in planning patient care</td>
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<td>19.</td>
<td>Have a good understanding of the roles and abilities of their teammates</td>
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<td>20.</td>
<td>Anticipate and predict each other’s needs</td>
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<td>21.</td>
<td>Have a lot of respect for each other</td>
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<td>22.</td>
<td>Enjoy working together</td>
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<td>23.</td>
<td>Exchange information clearly and concisely</td>
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<td>24.</td>
<td>Use names frequently when communicating information or allocating tasks</td>
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<tr>
<td><strong>Global rating</strong></td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td>SD</td>
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<td>25.</td>
<td>Overall, the theatre teams I work in demonstrate effective teamwork and communication behaviours</td>
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</table>

**Comments**

Which hospital are you completing this survey for?

What is your role in the operating theatre? (Please tick one)

- Consultant surgeon
- Consultant anaesthetist
- Anaesthetic technician
- Other (please specify)
- Surgical registrar/fellow
- Anaesthetic registrar/fellow
- Theatre nurse

Male ☐ Female ☐

Which of the following best describes your ethnicity? (Please tick one)

- New Zealand European
- Pacific Peoples
- Asian Indian
- Other (please specify)
- Māori
- Asian
- Other European

Thank you for taking the time to complete this survey
1. Setting the Stage

The Checklist is initiated appropriately.

<table>
<thead>
<tr>
<th>Poor</th>
<th>Excellent</th>
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</table>

**ESTABLISHING READINESS**
- Checklist reader starts reading out Checklist items without establishing readiness of participants.
- Sign In is begun while one or more of the team are doing other things (e.g., the anaesthetist is inserting a line).
- Sign In starts by the Checklist initiator raising his or her voice rather than establishing readiness.
- Sign In is begun after the induction of anaesthesia.

**Examples**
- Checklist reader starts reading out Checklist items without establishing readiness of participants.
- Sign In is begun while one or more of the team are doing other things (e.g., the anaesthetist is inserting a line).
- Sign In starts by the Checklist initiator raising his or her voice rather than establishing readiness.
- Sign In is begun after the induction of anaesthesia.

**Comments:**

2. Team Engagement

All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

<table>
<thead>
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<th>Poor</th>
<th>Excellent</th>
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</table>

**SUPPORTIVE**
- Anaesthetist says something unsupportive like “How long is this going to take? I need to get on with some real work.”

**ENGAGEMENT**
- A key team member is absent from the room during Sign In (e.g., the anaesthetist).
- Anaesthetist and/or nurse continue doing their work, attempting to multi-task.
- Any person in the room conducting conversations, speaking on the phone, hooking up equipment, and so on instead of concentrating on the Sign In.

**Examples**
- Anaesthetist says something unsupportive like “How long is this going to take? I need to get on with some real work.”
- A key team member is absent from the room during Sign In (e.g., the anaesthetist).
- Anaesthetist and/or nurse continue doing their work, attempting to multi-task.
- Any person in the room conducting conversations, speaking on the phone, hooking up equipment, and so on instead of concentrating on the Sign In.

**Comments:**

3. Communication: Activation

Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

<table>
<thead>
<tr>
<th>Poor</th>
<th>Excellent</th>
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</thead>
</table>

**COMMUNICATION**
- No names are used.
- Speaking softly indicating a private rather than shared conversation.

**INCLUSIVENESS**
- Senior team member makes a derogatory remark when someone asks a safety-related question or points out an important fact.
- Body language is exclusory (e.g., no eye contact) or hostile (e.g., angry expression).

**Examples**
- No names are used.
- Speaking softly indicating a private rather than shared conversation.
- Senior team member makes a derogatory remark when someone asks a safety-related question or points out an important fact.
- Body language is exclusory (e.g., no eye contact) or hostile (e.g., angry expression).

**Comments:**
4. Communication: Problem
Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

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<th>1</th>
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**Poor**

**PATIENT INFORMATION**
- The nurse reminds the team that the patient is allergic to several drugs *after* the induction drugs have been administered.

**EXPRESSED CONCERN**
- Uncertainty is expressed about the potential for blood loss, but no one speaks with the surgeon to check.
- Anaesthetist pays no attention and fails to respond to the question even by saying something like “I have no concerns.”
- Surgeon says something like “There is no time for this—people should know what to expect.”
- The anaesthetist says that there is a potential difficulty with intubation but is not provided adequate assistance or support or time to deal with this problem.

**Comments:**

**Excellent**

**PATIENT INFORMATION**
- Team member points out a potentially important clinical fact about the patient (e.g., “this patient has diabetes”)
- Surgeon says something like “Jim [to anaesthetist] you do know this patient’s uncle had problems with anaesthesia, don’t you?”
- Surgeon asks something like “does anyone know anything else about this patient that might worry us?”

**EXPRESSED CONCERN**
- In response to airway question, anaesthetist says that there may be difficulty, and makes sure that the difficult airway trolley is in the room and that there is adequate assistance on hand.
- In response to airway question, anaesthetist says something like “Airway is fine.”
- Anaesthetist says something like “I have no concerns about this patient.”
- Nurse says something like “Jim [to anaesthetist], are you worried about that IV? I wonder if it is big enough if we get into trouble with blood loss.”

5. Communication: Process
Completion

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

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**Poor**

**PROCESSES & PROCEDURES**
- Anaesthetist fails to acknowledge one or more of the questions about airway, the readiness of anaesthetic machine, blood loss, etc.
- All of the team state that side is correct without anyone checking surgical site marking.

**Comments:**

**Excellent**

**PROCESSES & PROCEDURES**
- Site confirmed as marked and visible by nurse, anaesthetist and surgeon.
- Checklist reader checks patient name and number with team members referring to patient’s wristband.
- Anaesthetist crosschecks site verification with patient (if not too sedated), saying something like “Mrs Smith, can you just confirm for me, one more time, which knee we are operating on?”
### 1. Setting the Stage

The Checklist is initiated appropriately.

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<td>Establishing Readiness</td>
<td>Establishing Readiness</td>
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<tr>
<td>• The Checklist reader starts reading out Checklist items without establishing readiness of participants.</td>
<td>• The Checklist initiator says something like “Is everyone able to take a couple of minutes for the Checklist?” or (to an individual) “Are you free to do the Time Out now or should we wait a minute or two?”</td>
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<td>• Time Out is begun while one or more of the team are doing other things (e.g., assembling the sterile field, assessing anaesthesia).</td>
<td>• The Checklist initiator says something like “Can we do the Time Out now, please? Is everyone ready to take part?”</td>
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<td>• Time Out is initiated after the first surgical incision.</td>
<td>• Time Out is called at the end of prepping and draping, prior to surgical incision.</td>
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Manner

- Checklist is read quickly and the answers are assumed without pausing to check that the surgeon and anaesthetist agree with the answers.
- Checklist is read quickly and the answers are assumed without checking that the surgeon and anaesthetist agree with the answers.

**Comments:**

### 2. Team Engagement

All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

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<td>• Someone says something like “This is a waste of time.”</td>
<td>• Surgeon or anaesthetist says something like “Thank you, Jane [to checklist reader]. Could everyone pay attention please? This is important.”</td>
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<td>• Key members talk on the phone or to each other during Time Out.</td>
<td>• All team members stop other activities and concentrate on the Checklist.</td>
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<td>• The surgeon says something like “Let’s get on with the checklist,” but then walks out of the room while it is being administered.</td>
<td>• Someone asks a question about something that he or she did not understand.</td>
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<td>• Key members continue with preoperative tasks during the Checklist, attempting to multi-task.</td>
<td>• Anaesthetist refers to patient chart to verify critical patient information as it is read out.</td>
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<td>• The registrar occupies self with other activities instead of paying attention.</td>
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**Comments:**

### 3. Communication: Activation

Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

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<td>• Some team members state name but not role during introductions.</td>
<td>• Every OR team member clearly states name and role during introductions.</td>
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<td>• Communication during the Checklist process is undirected, even by body language, and people speak to “thin air” rather than to each other.</td>
<td>• The Checklist reader confirms that everyone knows each other, perhaps because introductions occurred in a previous case.</td>
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<td>• Senior team member makes a derogatory remark when someone asks a question they might have been expected to know the answer to.</td>
<td>• Every person in the OR is acknowledged during the introductions.</td>
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<td>• Observers such as students are ignored and not introduced.</td>
<td>• Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.</td>
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<tr>
<td>• A negative remark is made about someone raising a patient safety concern.</td>
<td>• Circulating nurse is given opportunity to view consent form prior to first incision and confirms it aloud to all team members.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**
4. Communication: Problem Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

**Poor**

**Patient Information**
- Procedure is not delayed although an item of potentially important information is missing.
- The surgeon indicates a potential for considerable bleeding, but the anaesthetist, who has inserted a small IV line, does not respond by supplementing this.
- Surgeon says something like “Can we just get on with the procedure please—people should know what to expect.”

**Expressed Concern**
- Surgeon says something like “Although this patient is not diabetic, he is obese and this may be a stressful operation. Can you please check blood glucose levels after we have begun to be sure he is not becoming hyperglycemic?”
- Anaesthetist says something like “This patient has ischemic heart disease so I am worried about a myocardial infarction.”
- Surgeon says something like “OK, just a ‘heads up.’ This patient’s tissues are likely to be really poor, and I think I might have real problems with bleeding around the aorta.”
- Willingness is shown to delay procedure to get information needed.

**Excellent**

**Patient Information**
- Surgeon says to anaesthetist something like “This should be routine today—I have no concerns.”
- Surgeon confirms the procedure which will be done and indicates whether there is anything out of the ordinary about this case.
- Surgeon confirms with nursing team that any necessary special equipment or supplies are available before patient is induced.
- Surgeon states, “I would not expect a transfusion to be needed for this procedure. Can you please inform me if we get to a situation where you think this is indicated?”
- Surgeon makes team aware that he/she is on call and there may be interruptions during the case, and the team decide on a mechanism to field bleeps / calls / interruptions.

**Comments:**

5. Communication: Process Completion

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

**Poor**

**Processes & Procedures**
- Anaesthetist says something like “Oh thanks—I just giving the antibiotic now”, but surgeon says something grumpy and proceeds to make incision anyway, without waiting for this to happen (i.e., he ignores the message).
- The Checklist reader asks “Has antibiotic been given within last 60 minutes?” There is no response, but reader carries on with Checklist regardless.
- All of the team state that side is correct without anyone checking surgical site marking.

**Examples**

**Excellent**

**Processes & Procedures**
- Anaesthetist says something like “Sorry, I was distracted—I will just give the antibiotic now”, and surgeon says something like “OK, thanks for that,” waits for it to be given and allows some time for it to work before making an incision.
- The Checklist reader prompts team members for further information, such as lack of clarity over confirmation that the patient has had thrombo-prophylaxis.
- Surgeon asks anaesthetist, “Can you please tell me the antibiotic which was given, which one, how much, and at what time.”
- Surgeon and anaesthetist check key blood products are available.
- Patient's identification is re-checked and verified.

**Comments:**
### 1. Setting the Stage

The Checklist is initiated appropriately.

<table>
<thead>
<tr>
<th>Poor ESTABLISHING READINESS</th>
<th>Excellent ESTABLISHING READINESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Sign Out is done after surgeon has left the room or has left the table and is trying to do something else like write the operation note.</td>
<td>- The Checklist initiator says something like “Can we do the Sign Out now, please? Is everyone ready to take part?”</td>
</tr>
<tr>
<td>- The Checklist reader starts reading out checklist items without establishing readiness of participants.</td>
<td>- Sign Out is initiated as skin is being closed with all team members present and able to participate.</td>
</tr>
<tr>
<td>- Sign Out is performed when all team members are present, but during the transfer of the patient from table to bed, i.e. with no “pause.”</td>
<td>- Checklist initiator says something suggesting personal interest or commitment to the checklist, e.g., “listen up folks, checklist time,” in a tone of voice that suggests all have to pay attention.</td>
</tr>
</tbody>
</table>

**MANNER**

- Checklist reader uses tone of voice that suggests apathy, disinterest or disdain for the checklist process.

**Comments:**

### 2. Team Engagement

All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

<table>
<thead>
<tr>
<th>Poor ENGAGEMENT</th>
<th>Excellent SUPPORTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Surgeon has already left theatre.</td>
<td>- The surgeon says something like “I am going to let the resident close. Would it be OK to do the sign out now and then I can go and see the next patient while the rest of you finish off?”</td>
</tr>
<tr>
<td>- Surgeon says “You guys take care of this” and walks out.</td>
<td>- All team members stop other activities and concentrate on the Checklist.</td>
</tr>
<tr>
<td>- Scrub nurse continues to tidy instruments and ignores process.</td>
<td>- Scrub nurse stops all other activity and says something like “Are we all sure this patient’s coags are okay? He still looks pretty wet to me.”</td>
</tr>
<tr>
<td>- Anaesthetist and/or nurse continue doing their work, attempting to multi-task.</td>
<td>- Anyone asks a question about some aspect of the patient’s care.</td>
</tr>
</tbody>
</table>

**Comments:**

### 3. Communication: Activation

Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

<table>
<thead>
<tr>
<th>Poor INCLUSIVENESS</th>
<th>Excellent INCLUSIVENESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Senior team member makes a derogatory remark when someone asks a question they might have been expected to know the answer to.</td>
<td>- Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.</td>
</tr>
<tr>
<td>- During Sign Out, the anaesthetist indicates the need for additional time to ensure patient is safe but receives an unsupportive response.</td>
<td>- Nurse indicates that swab count is not correct and surgeon thanks him or her for helping to avoid a problem.</td>
</tr>
<tr>
<td>- Nurse indicates swab count is not correct and receives a critical or unsupportive response.</td>
<td>- The swab count indicates a missing swab, and the surgeon says something like “Thanks—we had better have another look behind the heart.”</td>
</tr>
</tbody>
</table>

**Comments:**
### 4. Communication: Problem Anticipation

**Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.**

<table>
<thead>
<tr>
<th>Poor</th>
<th>Excellent</th>
</tr>
</thead>
</table>

**EXPRESSED CONCERN**
- Team member speaks up about potential difficulty with equipment for the next procedure and receives an unsupportive or critical comment from the surgeon.
- Information about a potential problem is ignored.
- A nurse indicates that the swab count is correct, but there is no response to confirm that the surgeon has heard.

**PATIENT INFORMATION**
- Surgeon says to resident who will be writing orders, “Remember that this patient has an epidural, so our anticoagulation can only be unfractionated subcutaneous heparin until after the epidural is removed.”
- Surgeon says to anaesthetist, “This patient may have significant pain problems, so a dose of ketorolac now might be helpful for early postoperative pain relief.”

**Examples**
- An anaesthetist comments to scrub nurse, after surgeon has left, something like “I was a bit worried about patient’s post op pain management because epidural wasn’t working, but I didn’t want to bother the surgeon.”

**Comments:**

### 5. Communication: Process Completion

**Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.**

<table>
<thead>
<tr>
<th>Poor</th>
<th>Excellent</th>
</tr>
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</table>

**PROCESS & PROCEDURES**
- Specimen is (or has been) sent off without checking label.
- The swab count shows a missing swab, and the surgeon says something like “You guys can’t count” and proceeds to close anyway.
- Nurse indicates that the swab count is correct, but there is no response to confirm that the surgeon has heard.

**Examples**
- Instrument and swab count completed and persistent search is carried out for a missing item until it is found.
- Surgeon checks that the team have stored and labelled the specimens correctly.
- Surgeon requests circulator to read the label (specimen and patient name) on the specimen to confirm that it is correct.

**Comments:**
Evaluation of the effect of multidisciplinary simulation-based team training on patients, staff and organisations: protocol for a stepped-wedge cluster mixed methods study of a national, insurer-funded initiative for surgical teams in New Zealand public hospitals.

<table>
<thead>
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<tr>
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<td>Protocol</td>
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<td>Date Submitted by the Author</td>
<td>15-Oct-2019</td>
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</table>
| Complete List of Authors | Weller, Jennifer; The University of Auckland, Centre for Medical and Health Sciences Education  
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| Primary Subject Heading | Medical education and training |
| Secondary Subject Heading | Surgery |
| Keywords | SURGERY, simulation, teamwork, Protocols & guidelines < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, patient safety |
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Title

Evaluation of the effect of multidisciplinary simulation-based team training on patients, staff and organisations: protocol for a stepped-wedge cluster mixed methods study of a national, insurer-funded initiative for surgical teams in New Zealand public hospitals.

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Author contributions

JMW and AFM conceived the original proposal and drafted the original manuscript. JMW, AFM, JAL, PB, DC, CF, ALG, MRM, CSW contributed to the development and refinement and statistical analysis of the protocol. All authors critically appraised the drafted manuscript and made important intellectual contributions to the writing. All authors read and approved the final submitted manuscript.
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Abstract

Introduction

NetworkZ is a national, insurer-funded multidisciplinary simulation-based team-training programme for all New Zealand surgical teams. NetworkZ is delivered in situ, utilising full-body commercial simulators integrated with bespoke surgical models. Rolled out nationally over four years, the program builds local capacity through instructor training and provision of simulation resources.

We aim to improve surgical patient outcomes by improving teamwork through regular simulation-based multidisciplinary training in all New Zealand hospitals.

Methods and analysis

Our primary hypothesis is that surgical patient outcomes will improve following NetworkZ. Our secondary hypotheses are that teamwork processes will improve, and treatment injury claims will decline. In addition, we will explore factors that influence implementation and sustainability of NetworkZ and identify organisational changes following its introduction.

The study utilises a stepped-wedge cluster design. The intervention will roll out at yearly intervals to four cohorts of five District Health Boards (DHB). Allocation to cohort was purposive for year 1, and subsequently randomised. The primary outcome measure is Days Alive and Out of Hospital at 90 days using patient data from an existing national administrative database.

Secondary outcomes measures will include analysis of post-operative complications and treatment injury claims, surveys of teamwork and safety culture, in-theatre observations, and stakeholder interviews.

Ethics and dissemination

We believe this is the first surgical team training intervention to be implemented on a national scale, and a unique opportunity to evaluate a nation-wide team-training intervention for
healthcare teams. By using a pre-existing large administrative data set, we have the potential to
demonstrate a difference to surgical patient outcomes. This will be of interest to those working in
the field of healthcare teamwork, quality improvement and patient safety.

New Zealand Health and Disability Ethic Committee approval (#16/NTB/143). Australian and New
Zealand Clinical Trials Registry ID ACTRN12617000017325.

Article summary

Strengths and limitations of this study

1. The study uses a mixed methods approach to test the effectiveness of the NetworkZ training
   intervention in the context of real-world implementation across an entire nation.

2. Our primary outcomes measure, Days Alive and Out of Hospital at 90 Days, is an holistic
   measure of surgical outcomes utilising routinely collected health data from a national
   administrative database.

3. Programme rollout follows a stepped wedge cluster design in which cohorts of sites move
   progressively from baseline to post-implementation states in random order.

4. Running the training programmes is subject to willingness of hospitals to participate, and their
   own constraints around dates and numbers of courses. This could compromise the purity of the
   stepped wedge design.

5. Possible confounding by another factor operating progressively over time is a limitation of our
   design.

Keywords

Surgery; patient safety; simulation; multidisciplinary; teamwork; protocol.
Background

Unintended harm to patients due to medical treatment is a major contributor to the global burden of disease.\textsuperscript{1} In a systematic review of studies assessing inpatient outcomes\textsuperscript{2} surgical procedures were associated with 39.6\% of all adverse events and were commonly associated with unintended injury during hospitalisation. Communication failures contribute to many medical mishaps\textsuperscript{3} and sentinel events. In one study communication failures affected about 30\% of team interactions in the operating theatre\textsuperscript{4}, and in another they contributed to 43\% of surgical errors.\textsuperscript{5} Even when operating theatre staff work hard to maintain good relationships and minimise tensions,\textsuperscript{6} disciplinary silos\textsuperscript{7} professional rivalries\textsuperscript{8} and hierarchy\textsuperscript{3} create barriers to effective communication.

The Agency for Healthcare Research and Quality recommends team training as a patient safety strategy.\textsuperscript{9} Team training has been shown to improve communication.\textsuperscript{10,11} There is some evidence that it can improve team processes, clinical processes, and potentially, patient outcomes.\textsuperscript{12,13} Team training has been shown to improve safety culture and encourage attitudes and behaviours commonly found in high reliability organisations.\textsuperscript{14} Simulation is frequently used in team training initiatives.\textsuperscript{15,16} This study protocol focuses on the evaluation of a national simulation-based team training initiative.

Healthcare for New Zealand’s population of 4.8 million people is provided through 20 District Health Boards (DHBs) of varying size, with the smallest servicing a population of around 32,000, and the largest servicing a population to over 600,000. Each DHB includes one or more publicly funded hospital. New Zealand has a national no-fault insurer, the Accident Compensation Corporation (ACC), which compensates accident victims who sustain injuries, including injuries following treatment (known as “treatment injuries”). The number and costs of treatment injuries has increased over the last 5 years. In 2015/16 ACC accepted 8,881 medical and surgical treatment injury claims, with incurred costs of NZ$418 million. In an effort to reduce the human and fiscal toll of these events ACC is investing NZ$45 million over a five-year period into initiatives to reduce treatment injuries, targeting surgery, surgical site infections, pressure injuries, and maternity
Ten million dollars of that investment is funding a multidisciplinary, simulation-based team training programme, NetworkZ.

The NetworkZ programme is run in situ in operating theatres with full surgical teams who normally work together, to be implemented in all public hospitals in New Zealand. The aim is to establish regular team simulations in each hospital operating department, supplemented by additional 30-60 minute workshops on speaking up, actively listening, structured recap and handover, and closed loop communication.

It is supported by the NetworkZ Instructor course, which trains DHB staff to deliver the programme in their DHB. A full description of the programme can be found at www.networkz.ac.nz and in Supplementary Material 1.

In a pilot study, 20 surgical teams from two large Auckland hospitals participated in NetworkZ at the University of Auckland (UOA) Simulation Centre for Patient Safety with positive participant evaluations and improved scores for observed teamwork. The national roll-out now offers an opportunity to test the impact of team training on surgical outcomes at a national level.

We propose that, for a team-training programme to have a widespread and lasting impact on teamwork and communication, it must meet a number of conditions. It should involve teams that normally work together, and take place in the workplace, and in their own environment. It should be developed and delivered by a multidisciplinary team. It should have a sound theoretical framework for teamwork, educational approach and implementation. It should be locally ‘owned’ and led (as opposed to being externally imposed) following the initial implementation phase and the training should be provided in a ‘sufficient dose’ to involve the majority of staff in the training.

The educational framework for NetworkZ draws on the work of Kolb and Boud on experiential learning and reflective practice, and embraces interprofessional learning, gaining insights into the beliefs and roles of others, challenging assumptions, and strengthening social bonds between group members. It draws upon an evidence-based model of the features of effective teamwork conceptualised by Salas and colleagues. The key features of this model are leadership,
adaptability, mutual performance monitoring, back-up behaviour and team orientation. The underpinning elements are a shared mental model, clear concise communication and mutual trust and respect.

Our implementation strategy builds on the work of Bate, and Dixon-Woods. Factors believed to foster successful implementation of initiatives such as ours include organisational support and a shared commitment to the programme, leadership engagement, staff empowerment and networking, engaging clinical champions, together with building intrinsic staff motivation.

Hence implementation of the NetworkZ programme will provide extensive initial support to local project and instructor teams, senior management engagement and resourcing and follow a train-the-trainers model for local embedding and long-term sustainability. Instructors attend a two-day instructor workshop, complete on-line learning package are provided with on-site feedback and assessment as they take over responsibilities for running the course. Initial DHB courses are led by NetworkZ faculty, mentoring local instructors to the point where they can run the courses independently. Ongoing monitoring of the quality of the simulation training is provided through centralised review of participant evaluations and end of course reports, instructor accreditation visits by NetworkZ faculty and regular advanced instructor courses. The implementation strategy is described in more detail in Supplementary Material 1.

The aim of NetworkZ is to improve outcomes for surgical patients by improving teamwork and communication in operating theatre teams through embedding regular simulation-based multidisciplinary team training in New Zealand hospitals.

Methods
In this study we will address the following hypotheses and research questions.
Primary Hypothesis

Our primary hypothesis is that surgical patient outcomes will be improved following the implementation of NetworkZ as manifested in days alive and out of hospital over 90 days (DAOH$_{90}$).

Secondary hypotheses

Our two secondary hypotheses are: (1) teamwork and communication processes will be improved and (2) the number and cost of ACC treatment injury claims will decline following the introduction of our training programme.

Qualitative research questions

We aim to: explore the factors that facilitate or impede implementation of NetworkZ; understand requirements for long-term sustainability; and identify the types of changes occurring in the workplace following the implementation of NetworkZ.

Trial design

This is a mixed methods study, utilising quantitative and qualitative data in a stepped wedge, cluster randomised quality improvement design (see Figure 1). There are four cohorts of five DHBs each. Randomisation process: The 20 DHBs were divided into five groups of similar population size, calculated from publicly available Ministry of Health data on population sized served by each DHB. The first cohort comprised one DHB purposively selected from each of these five groups on the basis of capacity to start implementation. Following this initial selection, a random DHB from each size group was then selected for Cohort 2 and then for Cohort 3. The remaining DHBs comprised Cohort 4. In other words, one DHB from each size group was randomised to start the programme at the beginning of intervention period 2, period 3, and period 4 (Cohorts 2, 3 and 4).

[Figure 1 about here]

Comparison of outcomes will be undertaken between the pre-intervention period (control) starting one year before the first NetworkZ course in Cohort 1 DHBs, and the post-intervention period ending one year after the end of the transition.
period in Cohort 4. The transition period runs from the start of the DHB training for a Cohort, and lasts for 15 months, during which at least one third of staff in that Cohort should have attended a course. We believe that the effects from the intervention will not clearly manifest until at least 15 months, by which time a significant proportion of the staff will be trained and experienced with the intervention.

No quantitative data will be collected during the transition period. We have chosen the stepped wedge cluster design because it lends itself to a staged quality improvement project in which individual participants cannot be randomised to intervention or control.27 (see Figure 1)

Study population

There are two distinct populations included in the study protocol: the population of surgical patients and the population of surgical staff.

Patient population.

We will include patients undergoing surgery in public hospitals in New Zealand between February 1st 2016 and April 30th 2022 for patient outcome measures. We will obtain outcome data for our primary hypothesis from the National Minimum Dataset (NMDS), a reliable administrative dataset collected by the New Zealand Ministry of Health. This data set provides a confidential and comprehensive record of all public hospital admissions and discharges in New Zealand, including demographics, ICD diagnoses, procedures, length of stay, and mortality associated with each admission. In 2017 the NMDS included 330,353 cases of publicly funded surgery.28 The funding for NetworkZ allowed us to provide the team training for five major surgical specialities: general, orthopaedics, urology, otorhinolaryngology and plastics.

For inclusion and exclusion criteria see Table 1.

Table 1. Inclusion and exclusion criteria for patients and hospital staff.

<table>
<thead>
<tr>
<th>Study inclusion criteria</th>
<th>Study exclusion criteria</th>
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</table>

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml
Surgical patient admissions

<table>
<thead>
<tr>
<th>Patient admissions that meet all of the following criteria:</th>
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</thead>
<tbody>
<tr>
<td>- receive surgery in the five targeted surgical specialities</td>
</tr>
<tr>
<td>- receive surgical intervention involving a full surgical team</td>
</tr>
<tr>
<td>- requiring an overnight stay</td>
</tr>
<tr>
<td>- receive regional or general anaesthesia</td>
</tr>
<tr>
<td>- admitted for surgery to a publically funded hospital that has been, or will be, involved in the NetworkZ programme.</td>
</tr>
</tbody>
</table>

All subsequent readmissions to any hospital facility within the following 90 days will also be included.

<table>
<thead>
<tr>
<th>Patient admissions that meet any of the following criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- admitted and discharged on the day of surgery</td>
</tr>
<tr>
<td>- admitted to private hospitals</td>
</tr>
<tr>
<td>- receiving endoscopy using operator supervised sedation</td>
</tr>
<tr>
<td>- procedures requiring local infiltration only</td>
</tr>
<tr>
<td>- patients admitted to stand-alone paediatric hospitals.</td>
</tr>
</tbody>
</table>

Hospital staff

<table>
<thead>
<tr>
<th>Public hospital staff working in one of the following roles:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- surgical specialists in the included five speciality groups</td>
</tr>
<tr>
<td>- anaesthetic specialists</td>
</tr>
<tr>
<td>- nursing staff working in operating theatres</td>
</tr>
<tr>
<td>- anaesthetic assistants (referred to as Anaesthetic Technicians in New Zealand)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hospital staff working as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- trainees in surgery or anaesthesia</td>
</tr>
<tr>
<td>- solely specialised paediatric hospital employees</td>
</tr>
<tr>
<td>- house surgeons (junior doctors not in specialist training programmes)</td>
</tr>
<tr>
<td>- health care assistants</td>
</tr>
<tr>
<td>- solely private hospital employees.</td>
</tr>
</tbody>
</table>

Patient sample size and power analysis

The sample will be all patients undergoing surgery in public hospitals during the study period who stay at least one night in hospital and are undergoing procedures in the included speciality groups. This number has been estimated from NMDS historical data to be in the order of 550,000 cases over the six-year study period.

Our sample size is primarily pragmatic. Both our design (i.e. stepped-wedge) and primary outcome variable (i.e. DAOH) present significant obstacles to conventional sample size calculations.

Nonetheless, we have undertaken an empirical power analysis on simulated data. We generated
smooth sampling distributions from historical data for each DHB. This historic data feature
the cohort structure of DHBs, and the within-DHB clustering of patients likely to be present in our future study data. We also generated versions of each distribution with
a difference imposed at given quantiles by either flattening or accentuating the peaks in the data
(i.e. a larger late peak means more patients with better DAOH). Using the recruitment parameters
of our study, we generated 1,000 synthetic datasets with a simulated intervention effect. We
compared the control and intervention groups using the Wilcoxon-Mann-Whitney U test, and
assessed the significance of the calculated statistic by randomly permuting sites between cohorts
1,000 times, as in Thompson, et al. 29. Our simulations indicate a greater than 95% power at $\alpha=0.05$
to detect an intervention effect of one or more DAOH at the median, and two or more DAOH at the
0.25 quantile. We may apply quantile regression risk-adjustment to statistically evaluate
differences of less than one DAOH (i.e. the minimum resolution of unadjusted DAOH data).

Operating theatre staff population
NetworkZ aims to train the majority of eligible staff working in the operating theatres of New
Zealand public hospitals. Because there are four Cohorts with a staged annual roll out from 2017 to
2020 inclusive, the expected proportion of eligible operating theatre staff attending training over
the study period are: 100% of Cohort 1; 75% of Cohort 2; 50% of Cohort 3; 25% of Cohort 4, and
this is the basis of our sample size estimate. For surveys the unit of analysis will be the individual,
while for observations, the unit of analysis will be the theatre team. See Table 1 for inclusion and
exclusion criteria.

Total surgical staff population size
From specialist registration boards and hospital staffing lists we estimate the following: specialist
surgeons ~730; specialist anaesthetists ~750; operating theatre nurses ~1800; anaesthetic
technicians ~480. (Total = ~ 3,800 staff)
Operating theatre staff sample size estimate

For surveys, we will include all staff meeting the inclusion criteria. We will rate between 5 and 10 cases in each DHB in the three-month period prior to the introduction of NetworkZ in that DHB and immediately following the transition period in that DHB. Over the course of the study this will generate between 100 and 200 in the pre-NetworkZ period and a similar number in the post-NetworkZ period. Previous work indicates that fewer than 20 cases before and 20 after an intervention can detect a difference of one point on the seven-point WHOBARS scale in 80% of cases. We are undertaking more observations to obtain a representative sample across DHBs.

Outcome measures

Primary outcome measure (addressing primary hypothesis)

The primary outcome measure for the study is Days Alive and out of Hospital after 90 days (DAOH\textsubscript{90}), recently validated for the surgical context.\textsuperscript{31} DAOH provides a holistic approach to measuring patient harm that incorporates mortality and length of time out of hospital for a defined number of days (in this case 90 days) following an index event (in this case, a surgical procedure).\textsuperscript{32} Days in hospital include those until discharge following surgery, and those during any readmissions to public hospitals within the specified 90-day postoperative period. DAOH\textsubscript{90} scores will be affected by mortality and any complications that either prolong hospitalisation or result in readmission. DAOH\textsubscript{90} score will be zero for patients who die without ever leaving hospital, but any day alive and out of hospital during the 90-day period will be counted.

Index procedures for DAOH\textsubscript{90} will be limited to patients who stay in hospital for at least one night. The rationale for this is to restrict the patient population to those at higher risk of adverse events, and to increase the likelihood that when a patient is admitted for a diagnostic procedure prior to definitive surgery, the 90-day period begins with this definitive surgery. A surgical admission within 90 days will be subtracted from the 90 days when calculating DAOH\textsubscript{90}. The analysis will adjust for time (month and year of procedure), cohort, DHB (within cohort) and intervention, with the...
primary comparison using the cohort as the replicate of the intervention effects. Additionally, we will explore the influence of the proportion of staff in each DHB who have attended a NetworkZ course. In a secondary analysis we will also calculate Days out of Hospital and Mortality separately to tease out the individual effects of these on the primary outcome. The analysis will follow the procedure for the analysis of the primary outcome measure.

**Statistical analysis**

Using the Stepped Wedge cluster design we will analyse the differences between pre- and post-NetworkZ cohorts on each of the patient outcome measures. Data will be classified into pre-NetworkZ (control), transition, and post-intervention intervention categories (see Figure 1).

Due to the highly skewed and bimodal nature of the DAOH scores (see Figure 2), we will use the non-parametric Wilcoxon-Mann-Whitney rank sum test as our primary test to derive a statistic for the overall difference between distributions before and after implementation of NetworkZ. To assess the significance of the difference, we will compare the statistic to the values derived from 10,000 random permutations of cluster (i.e. DHB) to sequences (i.e. cohorts). We will then perform quantile regression at the 0.1, 0.25, 0.75, 0.9 quantile to characterize any difference between the two distributions. This quantile regression will include time (month and year of procedure) in order to adjust for time effects, cohort, DHB (within cohort) and intervention as factors in the model. To assess the impact of the purposive sampling of Cohort 1 DHBs, we will conduct a sensitivity analysis by re-running the above analysis using Cohort 2, 3, and 4 data.

[Figure 2 about here]

**Secondary outcome measures (addressing secondary hypotheses)**

**Teamwork Perceptions Survey**

The Teamwork Perceptions Survey was designed to align with the intended learning outcomes of NetworkZ (Supplementary material 2). Items were drawn from behaviours of effective teams
described by Salas and refined through review and consensus with an expert group. The survey will be administered to all operating theatre staff who are regularly working in operating theatres in the specialities targeted by the course.

This survey will be administered in the 3-month period prior to a DHB commencing training and repeated at the end of the transition period (at 15 months). Staff in DHBs around the country will be assigned unique confidential identifiers. These identifiers will be used in the surveys to enable matching of participants' pre- and post- intervention survey responses and determine if they have participated in NetworkZ.

Analysis

Pre- and post-Teamwork Perceptions Survey total scores and subscale scores will be assessed using a Generalized Linear Mixed Model (GLMM). The analysis will include terms for cohort, DHB (within cohort) and intervention, with the primary comparison using the cohort as the replicate of the intervention effects. Additionally, we will explore the influence of the proportion of staff in each DHB who have been trained.

Surgical Safety Culture Survey (SSCS)

The SSCS measures attitudes and behaviours relevant to surgical safety and survey scores have been shown to predict 30-day risk of post-operative death. The Health Quality and Safety Commission (HQSC) has made minor changes to the survey terminology for the New Zealand context. HQSC administers this national survey to all operating theatre staff on a bi-annual basis. The survey is anonymous but includes demographics such as DHB and professional role. HQSC administered the survey in February 2017 with subsequent administrations planned for February 2019 and February 2021.

Analysis

Pre- and post-SCSS total scores and subscale scores will be assessed using a GLMM. The analysis will include terms for cohort, DHB (within cohort) and intervention, with the primary comparison using the cohort as the replicate of the intervention effects.
Observations of WHO Surgical Safety Checklist administration

We will utilise the World Health Organisation Behaviourally Anchored Rating Scale (WHOBARS) observation tool previously developed and validated by members of our research group (see Supplementary material 3). WHOBARS measures the quality of administration of the Surgical Safety Checklist (SSC). The SSC is used almost universally in New Zealand and provides a standardised opportunity to share important information with other members of the surgical team. Changes in teamwork and communication should be reflected in this measure. Case selection for the WHOBARS observations will be a convenience sample of available cases over a 3-day rating period in each DHB and will include any surgical case that falls within the eligibility criteria for NetworkZ.

We will record unique staff identifiers for each team observed to enable post-NetworkZ influence of the number and role of staff in a team who have participated in a NetworkZ course. In order to generate reliable scores we will train raters using a series of videos and actual theatre cases.

Analysis

The analysis will compare mean and subscale WHOBARS scores for surgical teams pre- and post-the NetworkZ intervention using a GLMM. The analysis will include terms for cohort, DHB (within cohort) and intervention, with the primary comparison using the cohort as the replicate of the intervention effects. We will also undertake an exploratory analysis to investigate if the proportion of staff trained moderates the difference between pre- and post-training.

Number and costs of ACC treatment injury claims

To provide an indication of the fiscal outcomes of the intervention, surgical treatment injury claims submitted to ACC will be analysed using claims that are relevant to the surgical specialties targeted by NetworkZ. We will exclude claims that relate to specialties not included in NetworkZ. We will analyse ACC data using the same patient population groups over the same time-periods as established for the stepped wedge design for the primary analysis. The analysis will compare claim data pre- and post- the NetworkZ implementation using a GLMM. The analysis will include terms for cohort, DHB (within cohort) and intervention, with the primary comparison using the cohort as
the replicate of the NetworkZ effects. We will conduct separate analyses for the number and cost of claims.

Post-operative complications captured in the NMDS

To provide secondary data around patient safety, we intend to examine post-operative complications available in the NMDS. The NMDS captures information about new diagnoses that emerged as a result of surgical complications and instances of medical misadventures during surgery that have been captured in medical notes. This data will be analysed using the same patient population groups over the same time periods as the primary analysis.

Sick leave records

Improved teamwork has the potential to reduce staff retention and the use of sick-leave. We will assess monthly OR staff time off from illness by DHB to assess if there are reductions in sick leave following introduction to the programme.

Qualitative measures (addressing qualitative research questions)

We will undertake interviews with each Cohort to address the three qualitative research questions. We will conduct semi-structured interviews with DHB staff involved in NetworkZ on the project team or as instructors. We will identify potential participants through the NetworkZ database and sampling will be purposive to include a range of views from large and small DHBs, from different professional groups, and those with different roles. Sampling will continue to the point of data sufficiency, when no new themes are emerging and existing themes are sufficiently described. We anticipate a sample size of 20-30 interviews per Cohort. Timing of interviews will be during the transition period, during the period of implementation of NetworkZ. Interviews will be transcribed and coded using NVivo prior to framework analysis or general thematic analysis.
Patient and public involvement

There was no patient or public involvement in the development of this study protocol.

Ethics and dissemination

This study has been approved by the New Zealand Health and Disability Ethic Committee (HDEC) (#16/NTB/143). The committee waived the requirement for individual patient consent.

The protocol was registered with the Australian and New Zealand Clinical Trials Registry (ANZCTR) on 5th January 2017 and last updated on 7 August 2018. The protocol title is “Evaluation of NetworkZ: Can multidisciplinary team-training improve the safety of surgery in New Zealand?” The Trial ID is ACTRN1261700017325 and the Universal Trial Number is U1111-1189-3992.

Discussion

NetworkZ is a nationwide response to the global need to improve the safety of surgical care. To our knowledge this will be the first occasion when a surgical team training initiative has been implemented on a national scale. Access to routinely collected health data at a national scale is key to the feasibility of our evaluation.

The unique features of NetworkZ team training include: interactive surgical models integrated with computerised full-body computerised manikins that allow all members of the surgical team to participate; in situ training using real teams in real operating theatres; providing simulation resources and instructor training to build local capacity to independently run the course.
**Strengths of the study**

This is a national study, involving multiple sites and large numbers. It is adequately powered to show a difference in DAOH if one exists. Access to high-quality data routinely-collected nationally on hospital events is a major strength, without which the study would not be feasible.

Our primary outcome measure, DAOH, is a relatively new measure for surgical patient outcomes, recently validated for the surgical context. DAOH provides a holistic evaluation of surgical outcomes that is sensitive to any cause of death, prolonged hospital stay or readmission. This measure can be reliably and cost-effectively derived from the data in the NMDS and is objective.

Stepped wedge cluster design is very suitable for quality improvement initiatives in which it is impossible (or at least highly impracticable) to randomise individual cases or participants. It is uniquely suited to initiatives that are rolled out over time.

Another strength of our study is the mixed methods approach. The secondary outcome measures and qualitative data can provide supporting evidence of change attributed to NetworkZ and provide complementary insights into whether the programme is working as intended and why the programme is or is not working.

**Weaknesses of the study**

Team training interventions may take time to have an effect and we may thus fail to detect an effect due to sampling too early. Due to the limited timeframe for implementation of training in the initial Cohort as dictated by our funding contract, Cohort 1 DHBs were not selected randomly, but were purposively selected as we had an existing relationship with those DHBs. There are anticipated limitations of exploring the effect of quality improvement initiatives in the real world, including implications for standardisation, randomisation and control groups. For example implementation of training depends on the willingness of DHBs to support NetworkZ, local staff to undertake the Instructor Training, and DHB staff to attend the courses.
Despite numerous measures to achieve consistent, high quality training, there are challenges in achieving standardisation of NetworkZ delivery in individual DHBs where the local staff take on the responsibility for implementing the program in their own environments.

Due to the potential for other factors progressively influencing patient outcomes over time, we will not be able to prove that the changes can be attributed to NetworkZ. This will be mitigated to some extent through the stepped wedge design and triangulation with measures of teamwork through surveys and observations.

Conclusion
With the financial support of our publicly funded Accident Compensation Corporation, the unique opportunity exists to implement and evaluate a nation-wide team-training initiative for full operating theatre teams in all public hospitals in New Zealand. By using a pre-existing large administrative data set, we have the potential to demonstrate a difference to surgical patient outcomes from this quality improvement team-training initiative.

Acknowledgements
The authors would like to express special gratitude to Kaylene Henderson, Jane Torrie, Richard Hamblin and Ian Civil for their tireless efforts in the development and delivery of the NetworkZ programme, and the ongoing support of its evaluation.

Data statement
At the conclusion of the study de-identified Teamwork Perceptions Survey data will be available on reasonable request from cmhseadmin@auckland.ac.nz, for a period of five years for academic purposes. Other data that will be utilised in this study either cannot be adequately de-identified or was obtained from third-party databases that the authors do not have authority to grant access to.
Conflict of interest statement

Dr. Merry is Chair of the Health Quality and Safety Commission NZ and a director of SaferSleep LLC.

Both Dr Merry and Dr Webster hold shares in SaferSleep LLC.

Funding

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References


Figure 1. The stepped-wedge cluster cohort design

Figure 2. Probability density graph for the distribution of DAOH based on historical data from 2011-07-01 to 2016-06-30 (blue dotted) and the same with a simulated difference of one day imposed at the median (red solid). Note square root transform on y-axis.
Cohort 1
Begins Feb 2017

Cohort 2
Begins Feb 2018

Cohort 3
Begins Feb 2019

Cohort 4
Begins Feb 2020

Key:

- Pre-NetworkZ (Control) period
- Transition period (15 months)
- Post-NetworkZ period
Supplementary material 1

The NetworkZ programme and implementation process

The NetworkZ course

The NetworkZ course full-day course comprising simulated scenarios, de briefs, presentations and group discussion the full-day NetworkZ course can be delivered as two half-day courses in order to minimise operational disruption and thus maximise acceptability. The long-term aim is for all operating theatre staff in New Zealand public hospitals to complete a full day of training at least every three years. The course is designed for the five surgical specialties with the largest number of surgeons: general, orthopaedics, otorhinolaryngology, urology and plastics. Obstetrics and gynaecology for which a simulation training programme (non-OR) already existed was not included.

Scenarios:

When implementation has been completed 25 simulated scenarios will have been developed from actual cases of co-morbid patients presenting for surgery with a range of conditions such as trauma, sepsis, abdominal and post-operative airway emergencies. Simulated scenarios last between 25 and 45 minutes and the scenarios are designed to be challenging and complex with multiple decision points for the entire team. Scenarios begin prior to induction of anaesthesia and include detailed case notes, supporting documentation, imaging and investigations. They take place in each team’s actual operating theatre using available anaesthetic and surgical equipment, drugs and fluids and other consumable items, with formalised strategies to manage known risks of in-situ simulation.(37) The simulations use the Laerdal 3G SimMan manikins (38) with moulage and custom built face masks and body suits, combined with surgical models to maximise fidelity, to convey different simulated patients and to provide appropriate surgical, anaesthetic and nursing tasks. Examples of the surgical models include a ruptured appendix, a traumatic leg amputation and, and a neck haematoma compromising the airway. The models permit surgical interventions including incision, haemorrhage...
control, suturing, resection, and anastomosis. The manikin is pre-programmed to convey patient status at various phases of the scenario with supervisory control to respond to unexpected participant actions. A full surgical team participates in each scenario including at least one specialist surgeon and one specialist anaesthetist, three theatre nurses and an anaesthetic assistant. Surgical and anaesthesia trainees often participate as do health care assistants and post-anaesthetic care unit nurses.

NetworkZ faculty observe from behind a partition, screen or via video-link (depending on local facilities). Faculty control the manikin and surgical models in response to participant actions and answer participant phone calls for assistance or advice following scripts which replicate local processes. The scenarios are not recorded and there are no participant observers.

Participants are supported by a ‘confederate’ nurse or anaesthetic assistant who is in communication with the instructional team. The confederate assists with clinical tasks in the simulated environment such as taking blood samples or by discreet communication of physical signs unable to be replicated by the manikin or models (e.g. deviated trachea).

Debriefing:
The scenario is followed by a facilitated debrief with 2 trained NetworkZ instructors using three distinct phases: Phase 1 participant reactions; Phase 2 description, analysis, application; Phase 3 personal transfer to practice. Questioning approaches emphasise open questions and advocacy enquiry. Debriefers refer to specific communication tools and teamwork behaviours from the Salas model with the aid of wall-mounted posters. Systems issues identified in the debrief are recorded and reported back to the local quality improvement leader for follow up.

Interactive Presentations:
Purpose-designed trigger videos and animations are used to emphasise communication strategies and specific tools for briefing the team. The strategies and tools include ISBAR, closed loop communication, speaking up, and structured recapping. Participants are encouraged to explore their
different professional roles, perspectives and assumptions to develop strategies to work together more effectively.

**NetworkZ instructor training**

The NetworkZ course quality is assured by the requirement for instructors to demonstrate competency in ten domains of practice, using Entrustable Professional Activities (EPAs)(41) as an organising framework for the curriculum. These domains are: fundamentals of effective teamwork; creating a safe learning environment; conducting a scenario; identifying learning points while observing a scenario; conducting a debrief; evaluating learning; managing risk with in situ simulation; preparing the clinical environment for simulation, operating the simulation equipment; and maintaining simulation resources.

The EPAs are mastered using a blended approach to course delivery that includes face-to-face workshops, online learning and apprentice-ship style learning with observation and feedback from senior faculty. Instructor assessment includes online submissions and assessment of performance.

**Implementation strategy**

Our approach to implementation is multifaceted, incorporating multiple stakeholders; national bodies included central committees of the 20 New Zealand District Health Board (DHB) executives, the Royal Australasian College of Surgeons, the Australian and New Zealand College of Anaesthetists; New Zealand Nursing Council; and Institute of Anaesthetic Technicians. Approximately 12 months prior to the introduction of NetworkZ, the NetworkZ project team meet the DHB senior executive team, and negotiate a formal letter of agreement with the Chief Executive. This outlines the gift of a 3G Laerdal simulator and some surgical models to the DHB, provision of training and support by the NetworkZ project team and the expectations of DHB support for release of staff to attend training with provision of the training venue. In each DHB local project teams are established with connections to senior executive and quality assurance leads. A local group of instructors are nominated and undertake training. NetworkZ training in the DHB is initially supported by UOA faculty but gradually devolved
to local DHB instructors as they complete NetworkZ instructor training. After 12 to 15 months, DHBs assume full responsibility for running the NetworkZ course in their DHB. UOA maintains a role in quality improvement, quality monitoring, instructor training and course development.
Teamwork Perceptions Survey

Please rate the following components of teamwork in the operating theatre teams where you regularly work. We acknowledge that your experiences will vary between different theatre teams. Please try to give an average rating for your experiences of teamwork across the theatres where you regularly work, rather than rating one specific theatre team.

Please note this is about the whole theatre team, including surgeons, nurses, techs and anaesthetists.

SA = Strongly Agree; A=Agree; N=Neutral; D=Disagree; SD=Strongly Disagree

<table>
<thead>
<tr>
<th>In general, in theatres where I regularly work, senior staff (e.g. consultant surgeon and anaesthetist, senior nurse, charge tech):</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
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<tbody>
<tr>
<td>1. Provide clear directions to the team</td>
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<td>2. Use an appropriate balance of assertiveness and support</td>
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<td>3. Motivate team members to do their best</td>
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<td>4. Establish a positive atmosphere in theatre</td>
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<td>5. Facilitate team problem solving during the case</td>
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<td>6. Role model acceptable interaction with colleagues</td>
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<td>7. Engage in pre case briefings of the whole team</td>
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<td>8. Co-ordinate tasks and individual team member contributions to patient care</td>
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<tr>
<th>Team members:</th>
<th>SA</th>
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<td>9. Provide support to each other</td>
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<td>10. Shift work responsibilities to underutilised team members at times of high workload</td>
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<td>11. Keep an eye on other team members’ performance</td>
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<td>12. Speak up about potential mistakes or lapses in other team members’ plans or actions</td>
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<td>13. Provide constructive feedback regarding team member actions to facilitate self-correction</td>
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<td>14. Are willing to acknowledge mistakes and accept feedback</td>
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<td>15. Value the input of all team members to patient care</td>
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<td>16. Take into account alternative solutions offered by other team members</td>
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</table>
17. Share information about the case planning, progress and concerns with other team members

18. Involve the whole team in planning patient care

19. Have a good understanding of the roles and abilities of their teammates

20. Anticipate and predict each other’s needs

21. Have a lot of respect for each other

22. Enjoy working together

23. Exchange information clearly and concisely

24. Use names frequently when communicating information or allocating tasks

Global rating

SA  A  N  D  SD

25. Overall, the theatre teams I work in demonstrate effective teamwork and communication behaviours

Comments

Which hospital are you completing this survey for?
__________________________________________________________

What is your role in the operating theatre? (Please tick one)

Consultant surgeon  
Consultant anaesthetist  
Anaesthetic technician  
Other (please specify)  
Surgical registrar/fellow  
Anaesthetic registrar/fellow  
Theatre nurse

Male  
Female

Which of the following best describes your ethnicity? (Please tick one)

New Zealand European  
Pacific Peoples  
Asian Indian  
Other (please specify)  
Māori  
Asian  
Other European

Thank you for taking the time to complete this survey
WHOBARs: SIGN IN [A]

Sign In not done at all □

1. Setting the Stage

The Checklist is initiated appropriately.

Poor

ESTABLISHING READINESS
- Checklist reader starts reading out Checklist items without establishing readiness of participants.
- Sign In is begun while one or more of the team are doing other things (e.g., the anaesthetist is inserting a line).
- Sign In starts by the Checklist initiator raising his or her voice rather than establishing readiness.
- Sign In is begun after the induction of anaesthesia.

Excellent

ESTABLISHING READINESS
- The Checklist initiator says something like “Is everyone able to take a couple of minutes for the Checklist?” or (to an individual) “Are you free to do the Sign In now or should we wait a minute or two?”
- The anaesthetist says something like “I just need to finish this—can we wait a couple of minutes please?” The Checklist reader then waits until the anaesthetist is ready.
- Sign In is begun when patient first enters room before any drugs are administered.

Comments:

2. Team Engagement

All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

Poor

SUPPORTIVE
- Anaesthetist says something unsupportive like “How long is this going to take? I need to get on with some real work.”

ENGAGEMENT
- A key team member is absent from the room during Sign In (e.g., the anaesthetist).
- Anaesthetist and/or nurse continue doing their work, attempting to multi-task.
- Any person in the room conducting conversations, speaking on the phone, hooking up equipment, and so on instead of concentrating on the Sign In.

Excellent

SUPPORTIVE
- Anaesthetist says something supportive like “Thank you, Jane [to Checklist reader]. Could everyone pay attention please? This is important.”

ENGAGEMENT
- All team members stop other activities and concentrate on the Checklist.
- Surgeon, if present, participates at least by listening and by supportive body language.
- Patient, if not too sedated, has process explained and is invited to confirm key points.

Comments:

3. Communication: Activation

Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

Poor

COMMUNICATION
- No names are used.
- Speaking softly indicating a private rather than shared conversation.

INCLUSIVENESS
- Senior team member makes a derogatory remark when someone asks a safety-related question or points out an important fact.
- Body language is exclusory (e.g., no eye contact) or hostile (e.g., angry expression).

Excellent

COMMUNICATION
- Senior team member says something to the effect that she hopes that people will speak up if they see something they don’t understand or think there is a possible problem.
- Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.

INCLUSIVENESS
- Senior team member says something to the effect that she hopes that people will speak up if they see something they don’t understand or think there is a possible problem.
- Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.

Comments:
WHOBARS: SIGN IN [A]

4. Communication: Problem Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

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**Poor**

- PATIENT INFORMATION
  - The nurse reminds the team that the patient is allergic to several drugs after the induction drugs have been administered.

- EXPRESSED CONCERN
  - Uncertainty is expressed about the potential for blood loss, but no one speaks with the surgeon to check.
  - Anaesthetist pays no attention and fails to respond to the question even by saying something like “I have no concerns.”
  - Surgeon says something like “There is no time for this—people should know what to expect.”

- The anaesthetist says that there is a potential difficulty with intubation but is not provided adequate assistance or support or time to deal with this problem.

**Excellent**

- PATIENT INFORMATION
  - Team member points out a potentially important clinical fact about the patient (e.g., “This patient has diabetes”)
  - Surgeon says something like “Jim [to anaesthetist] you do know this patient’s uncle had problems with anaesthesia, don’t you?”
  - Surgeon asks something like “Does anyone know anything else about this patient that might worry us?”

- EXPRESSED CONCERN
  - In response to airway question, anaesthetist says that there may be difficulty, and makes sure that the difficult airway trolley is in the room and that there is adequate assistance on hand.
  - In response to airway question, anaesthetist says something like “Airway is fine.”
  - Anaesthetist says something like “I have no concerns about this patient.”

- In response to airway question, anaesthetist says something like “I have no concerns about this patient.”

- Nurse says something like “Jim [to anaesthetist], are you worried about that IV? I wonder if it is big enough if we get into trouble with blood loss.”

Comments:

5. Communication: Process Completion

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

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**Poor**

- PROCESSES & PROCEDURES
  - Anaesthetist fails to acknowledge one or more of the questions about airway, the readiness of anaesthetic machine, blood loss, etc.

- All of the team state that side is correct without anyone checking surgical site marking.

**Excellent**

- PROCESSES & PROCEDURES
  - Site confirmed as marked and visible by nurse, anaesthetist and surgeon.

- Checklist reader checks patient name and number with team members referring to patient’s wristband.

- Anaesthetist crosschecks site verification with patient (if not too sedated), saying something like “Mrs Smith, can you just confirm for me, one more time, which knee we are operating on?”

Comments:
### 1. Setting the Stage

#### The Checklist is initiated appropriately.

**Poor**
- Checklist reader starts reading out Checklist items without establishing readiness of participants.
- Time Out is begun while one or more of the team are doing other things (e.g., assembling the sterile field, assessing anaesthesia).
- Time Out is initiated after the first surgical incision.

**Examples**
- Checklist is read quickly and the answers are assumed without pausing to check that the surgeon and anaesthetist agree with the answers.

**Excellent**
- The Checklist initiator says something like "Is everyone able to take a couple of minutes for the Checklist?" or (to an individual) "Are you free to do the Time Out now or should we wait a minute or two?"
- The Checklist reader initiates something like "Can we do the Time Out now, please? Is everyone ready to take part?"
- Time Out is called at the end of prepping and draping, prior to surgical incision.

**Examples**
- The Checklist reader uses an assertive tone of voice conveying a commitment to the Checklist process.

**Comments:**

---

### 2. Team Engagement

#### All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

**Poor**
- Someone says something like "This is a waste of time."
- Key members talk on the phone or to each other during Time Out.
- The surgeon says something like "Let's get on with the checklist," but then walks out of the room while it is being administered.
- Key members continue with preoperative tasks during the Checklist, attempting to multi-task.
- The registrar occupies self with other activities instead of paying attention.

**Examples**
- The Checklist is initiated appropriately
- The Checklist reader uses an assertive tone of voice conveying a commitment to the Checklist process.

**Excellent**
- Surgeon or anaesthetist says something like "Thank you, Jane [to checklist reader]. Could everyone pay attention please? This is important."
- All team members stop other activities and concentrate on the Checklist.
- Someone asks a question about something that he or she did not understand.
- Anaesthetist refers to patient chart to verify critical patient information as it is read out.

**Examples**
- Every OR team member clearly states name and role during introductions.
- The checklist reader confirms that everyone knows each other, perhaps because introductions occurred in a previous case.

**Comments:**

---

### 3. Communication: Activation

#### Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

**Poor**
- Some team members state name but not role during introductions.
- Communication during the Checklist process is undirected, even by body language, and people speak to "thin air" rather than to each other.
- Senior team member makes a derogatory remark when someone asks a question they might have been expected to know the answer to.
- Observers such as students are ignored and not introduced.
- A negative remark is made about someone raising a patient safety concern.

**Examples**
- Every person in the OR is acknowledged during the introductions.
- Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.
- Circulating nurse is given opportunity to view consent form prior to first incision and confirms it aloud to all team members.
- Observers such as students are introduced.

**Excellent**
- Every OR team member clearly states name and role during introductions.
- The Checklist reader confirms that everyone knows each other, perhaps because introductions occurred in a previous case.

**Examples**
- Every person in the OR is acknowledged during the introductions.
- Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.
- Circulating nurse is given opportunity to view consent form prior to first incision and confirms it aloud to all team members.

**Comments:**
4. Communication: Problem

Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

<table>
<thead>
<tr>
<th>Poor</th>
<th>Excellent</th>
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**PATIENT INFORMATION**
- Procedure is not delayed although an item of potentially important information is missing.
- The surgeon indicates a potential for considerable bleeding, but the anaesthetist, who has inserted a small IV line, does not respond by supplementing this.
- Surgeon says something like "Can we just get on with the procedure please—people should know what to expect."

**EXPRESSED CONCERN**
- Surgeon says to anaesthetist something like "Although this patient is not diabetic, he is obese and this may be a stressful operation. Can you please check blood glucose levels after we have begun to be sure he is not becoming hyperglycemic?"
- Anaesthetist says something like "This patient has ischemic heart disease so I am worried about a myocardial infarction."
- Surgeon says something like "OK, just a 'heads up.' This patient’s tissues are likely to be really poor, and I think I might have real problems with bleeding around the aorta."
- Willingness is shown to delay procedure to get information needed.

**Comments:**

5. Communication: Process

Completion

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

<table>
<thead>
<tr>
<th>Poor</th>
<th>Excellent</th>
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**PROCESSES & PROCEDURES**
- Anaesthetist says something like "Oh thanks—just giving the antibiotic now", but surgeon says something grumpy and proceeds to make incision anyway, without waiting for this to happen (i.e., he ignores the message).
- The Checklist reader asks "Has antibiotic been given within last 60 minutes?" There is no response, but reader carries on with Checklist regardless.
- All of the team state that side is correct without anyone checking surgical site marking.

**Examples**
- Anaesthetist says something like "Sorry, I was distracted—I will just give the antibiotic now," and surgeon says something like "OK, thanks for that," waits for it to be given and allows some time for it to work before making an incision.
- The Checklist reader prompts team members for further information, such as lack of clarity over confirmation that the patient has had thrombo-prophylaxis.
- Surgeon asks anaesthetist, "Can you please tell me the antibiotic which was given, which one, how much, and at what time."
- Surgeon and anaesthetist check key blood products are available.
- Patient’s identification is re-checked and verified.

**Comments:**
### 1. Setting the Stage

*The Checklist is initiated appropriately.*

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<tr>
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<tbody>
<tr>
<td>1</td>
<td>ESTABLISHING READINESS</td>
<td>ESTABLISHING READINESS</td>
</tr>
<tr>
<td></td>
<td>• Sign Out is done after surgeon has left the room or has left the</td>
<td>• The Checklist initiator says something like “Can we do the Sign Out now, please? Is everyone ready to take part?”</td>
</tr>
<tr>
<td></td>
<td>table and is trying to do something else like write the operation</td>
<td>• Sign Out is initiated as skin is being closed with all team members present and able to participate.</td>
</tr>
<tr>
<td></td>
<td>note.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The Checklist reader starts reading out checklist items without</td>
<td>MANNER</td>
</tr>
<tr>
<td></td>
<td>establishing readiness of participants.</td>
<td>• Checklist initiator says something suggesting personal interest or commitment to the checklist, e.g., “listen up folks, checklist time,” in a tone of voice that suggests all have to pay attention.</td>
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<tr>
<td></td>
<td>• Sign Out is performed when all team members are present, but during</td>
<td></td>
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<td></td>
<td>the transfer of the patient from table to bed, i.e. with no “pause.”</td>
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<td>MANNER</td>
<td></td>
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<tr>
<td></td>
<td>• Checklist reader uses tone of voice that suggests apathy, disinterest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>or disdain for the checklist process.</td>
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**Comments:**

---

### 2. Team Engagement

*All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.*

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
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<tbody>
<tr>
<td>1</td>
<td>ENGAGEMENT</td>
<td>SUPPORTIVE</td>
</tr>
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<td></td>
<td>• Surgeon has already left theatre.</td>
<td>• The surgeon says something like “I am going to let the resident close. Would it be OK to do the sign out now and then I can go and see the next patient while the rest of you finish off?”</td>
</tr>
<tr>
<td></td>
<td>• Surgeon says “You guys take care of this” and walks out.</td>
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<td></td>
<td>• Scrub nurse continues to tidy instruments and ignores process.</td>
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<td></td>
<td>• Anaesthetist and/or nurse continue doing their work, attempting</td>
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<td></td>
<td>to multi-task.</td>
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**Comments:**

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### 3. Communication: Activation

*Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.*

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<tbody>
<tr>
<td>1</td>
<td>INCLUSIVENESS</td>
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<tr>
<td></td>
<td>• Senior team member makes a derogatory remark when someone asks a</td>
<td>• Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.</td>
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<tr>
<td></td>
<td>question they might have been expected to know the answer to.</td>
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<td></td>
<td>• During Sign Out, the anaesthetist indicates the need for</td>
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<td>additional time to ensure patient is safe but receives an</td>
<td></td>
</tr>
<tr>
<td></td>
<td>unsupportive response.</td>
<td></td>
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<tr>
<td></td>
<td>• Nurse indicates swab count is not correct and receives a</td>
<td></td>
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<td></td>
<td>critical or unsupportive response.</td>
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**Comments:**
4. Communication: Problem Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

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**Expressed Concern**
- Team member speaks up about potential difficulty with equipment for the next procedure and receives an unsupportive or critical comment from the surgeon.
- Information about a potential problem is ignored.

**Patient Information**
- Surgeon says to resident who will be writing orders, "Remember that this patient has an epidural, so our anticoagulation can only be unfractionated subcutaneous heparin until after the epidural is removed."
- Surgeon says to anesthetist, "This patient may have significant pain problems, so a dose of ketorolac now might be helpful for early postoperative pain relief."

**Expressed Concern**
- Anesthetist verbally discusses immediate and early postoperative measures to ensure patient safety.
- Surgeon verbally hands over instructions relating to drain outputs and early postoperative care.
- Specific elements of postoperative care are reviewed such as need for anticoagulants, postop antibiotics yes/no, pain management plans, need for special monitoring, etc.
- Surgeon says something like "I am worried this patient is oozing. John [to the anesthetist] could you ask the ward to organize a coagulation screen please?"
- Anesthetist says something like "Thanks. I really appreciate the opportunity to discuss this patient’s poor respiratory reserve—I think he might get into trouble overnight."

**Comments:**

5. Communication: Process Completion

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

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**Processes & Procedures**
- Specimen is (or has been) sent off without checking label.
- The swab count shows a missing swab, and the surgeon says something like "You guys can’t count" and proceeds to close anyway.
- Nurse indicates that swab count is correct, but there is no response to confirm that the surgeon has heard.

**Processes & Procedures**
- Instrument and swab count completed and persistent search is carried out for a missing item until it is found.
- Surgeon checks that the team have stored and labelled the specimens correctly.
- Surgeon requests circulator to read the label (specimen and patient name) on the specimen to confirm that it is correct.

**Comments:**
Evaluation of the effect of multidisciplinary simulation-based team training on patients, staff and organisations: protocol for a stepped-wedge cluster mixed methods study of a national, insurer-funded initiative for surgical teams in New Zealand public hospitals.

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<td>Protocol</td>
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<td>Date Submitted by the Author:</td>
<td>22-Nov-2019</td>
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| Complete List of Authors: | Weller, Jennifer; The University of Auckland, Centre for Medical and Health Sciences Education  
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Beaver, Peter; The University of Auckland, Centre for Medical and Health Sciences Education  
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Merry, Alan; The University of Auckland, Department of Anaesthesiology |
| Primary Subject Heading: | Medical education and training |
| Secondary Subject Heading: | Surgery |
| Keywords: | SURGERY, simulation, teamwork, Protocols & guidelines < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, patient safety |
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Title

Evaluation of the effect of multidisciplinary simulation-based team training on patients, staff and organisations: protocol for a stepped-wedge cluster mixed methods study of a national, insurer-funded initiative for surgical teams in New Zealand public hospitals.

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Author contributions
JMW and AFM conceived the original proposal and drafted the original manuscript. JMW, AFM, JAL, PB, DC, CF, ALG, MRM, CSW contributed to the development and refinement and statistical analysis of the protocol. All authors critically appraised the drafted manuscript and made important intellectual contributions to the writing. All authors read and approved the final submitted manuscript.

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Abstract

Introduction

NetworkZ is a national, insurer-funded multidisciplinary simulation-based team-training programme for all New Zealand surgical teams. NetworkZ is delivered in situ, utilising full-body commercial simulators integrated with bespoke surgical models. Rolled out nationally over four years, the program builds local capacity through instructor training and provision of simulation resources. We aim to improve surgical patient outcomes by improving teamwork through regular simulation-based multidisciplinary training in all New Zealand hospitals.

Methods and analysis

Our primary hypothesis is that surgical patient outcomes will improve following NetworkZ. Our secondary hypotheses are that teamwork processes will improve, and treatment injury claims will decline. In addition, we will explore factors that influence implementation and sustainability of NetworkZ and identify organisational changes following its introduction.

The study utilises a stepped-wedge cluster design. The intervention will roll out at yearly intervals to four cohorts of five District Health Boards (DHB). Allocation to cohort was purposive for year 1, and subsequently randomised. The primary outcome measure is Days Alive and Out of Hospital at 90 days using patient data from an existing national administrative database.

Secondary outcomes measures will include analysis of post-operative complications and treatment injury claims, surveys of teamwork and safety culture, in-theatre observations, and stakeholder interviews.

Ethics and dissemination
We believe this is the first surgical team training intervention to be implemented on a national scale, and a unique opportunity to evaluate a nation-wide team-training intervention for healthcare teams. By using a pre-existing large administrative data set, we have the potential to demonstrate a difference to surgical patient outcomes. This will be of interest to those working in the field of healthcare teamwork, quality improvement and patient safety. New Zealand Health and Disability Ethic Committee approval (#16/NTB/143). Australian and New Zealand Clinical Trials Registry ID ACTRN12617000017325.

**Article summary**

**Strengths and limitations of this study**

1. The study uses a mixed methods approach to test the effectiveness of the NetworkZ training intervention in the context of real-world implementation across an entire nation.

2. Our primary outcomes measure, Days Alive and Out of Hospital at 90 Days, is an holistic measure of surgical outcomes utilising routinely collected health data from a national administrative database.

3. Programme rollout follows a stepped wedge cluster design in which cohorts of sites move progressively from baseline to post-implementation states in random order.

4. Running the training programmes is subject to willingness of hospitals to participate, and their own constraints around dates and numbers of courses. This could compromise the purity of the stepped wedge design.

5. Possible confounding by another factor operating progressively over time is a limitation of our design.
Keywords
Surgery; patient safety; simulation; multidisciplinary; teamwork; protocol.
**Background**

Unintended harm to patients due to medical treatment is a major contributor to the global burden of disease.\(^1\) In a systematic review of studies assessing inpatient outcomes\(^2\) surgical procedures were associated with 39.6% of all adverse events and were commonly associated with unintended injury during hospitalisation. Communication failures contribute to many medical mishaps\(^3\) and sentinel events. In one study communication failures affected about 30% of team interactions in the operating theatre\(^4\), and in another they contributed to 43% of surgical errors.\(^5\) Even when operating theatre staff work hard to maintain good relationships and minimise tensions,\(^6\) disciplinary silos\(^7\) professional rivalries\(^8\) and hierarchy\(^3\) create barriers to effective communication.

The Agency for Healthcare Research and Quality recommends team training as a patient safety strategy.\(^9\) Team training has been shown to improve communication.\(^10\)\(^11\) There is some evidence that it can improve team processes, clinical processes, and potentially, patient outcomes.\(^12\)\(^13\) Team training has been shown to improve safety culture and encourage attitudes and behaviours commonly found in high reliability organisations.\(^14\) Simulation is frequently used in team training initiatives.\(^15\)\(^16\) This study protocol focuses on the evaluation of a national simulation-based team training initiative.

Healthcare for New Zealand’s population of 4.8 million people is provided through 20 District Health Boards (DHBs) of varying size, with the smallest servicing a population of around 32,000, and the largest servicing a population to over 600,000. Each DHB includes one or more publicly funded hospital. New Zealand has a national no-fault insurer, the Accident Compensation Corporation (ACC), which compensates accident victims who sustain injuries, including...
injuries following treatment (known as “treatment injuries”). The number and costs of treatment injuries has increased over the last 5 years. In 2015/16 ACC accepted 8,881 medical and surgical treatment injury claims, with incurred costs of NZ$418 million. In an effort to reduce the human and fiscal toll of these events ACC is investing NZ$45 million over a five-year period into initiatives to reduce treatment injuries, targeting surgery, surgical site infections, pressure injuries, and maternity care. Ten million dollars of that investment is funding a multidisciplinary, simulation-based team training programme, NetworkZ.

The NetworkZ programme is run in situ in operating theatres with full surgical teams who normally work together, to be implemented in all public hospitals in New Zealand. The aim is to establish regular team simulations in each hospital operating department, supplemented by additional 30-60 minute workshops on speaking up, actively listening, structured recap and handover, and closed loop communication.

It is supported by the NetworkZ Instructor course, which trains DHB staff to deliver the programme in their DHB. A full description of the programme can be found at [www.networkz.ac.nz](http://www.networkz.ac.nz) and in Supplementary Material 1.

In a pilot study, 20 surgical teams from two large Auckland hospitals participated in NetworkZ at the University of Auckland (UOA) Simulation Centre for Patient Safety with positive participant evaluations and improved scores for observed teamwork. The national roll-out now offers an opportunity to test the impact of team training on surgical outcomes at a national level.

We propose that, for a team-training programme to have a widespread and lasting impact on teamwork and communication, it must meet a number of conditions. It should involve teams that normally work together, and take place...
in the workplace, and in their own environment. It should be developed and delivered by a multidisciplinary team. It should have a sound theoretical framework for teamwork, educational approach and implementation. It should be locally ‘owned’ and led (as opposed to being externally imposed) following the initial implementation phase and the training should be provided in a ‘sufficient dose’ to involve the majority of staff in the training.

The educational framework for NetworkZ draws on the work of Kolb and Boud on experiential learning and reflective practice, and embraces interprofessional learning, gaining insights into the beliefs and roles of others, challenging assumptions, and strengthening social bonds between group members. It draws upon an evidence-based model of the features of effective teamwork conceptualised by Salas and colleagues. The key features of this model are leadership, adaptability, mutual performance monitoring, back-up behaviour and team orientation. The underpinning elements are a shared mental model, clear concise communication and mutual trust and respect.

Our implementation strategy builds on the work of Bate, and Dixon-Woods. Factors believed to foster successful implementation of initiatives such as ours include organisational support and a shared commitment to the programme, leadership engagement, staff empowerment and networking, engaging clinical champions, together with building intrinsic staff motivation. Hence implementation of the NetworkZ programme will provide extensive initial support to local project and instructor teams, senior management engagement and resourcing and follow a train-the-trainers model for local embedding and long-term sustainability. Instructors attend a two-day instructor workshop, complete on-line learning package are provided with on-site feedback and assessment as they take over responsibilities for running the course. Initial
DHB courses are led by NetworkZ faculty, mentoring local instructors to the point where they can run the courses independently. Ongoing monitoring of the quality of the simulation training is provided through centralised review of participant evaluations and end of course reports, instructor accreditation visits by NetworkZ faculty and regular advanced instructor courses. The implementation strategy is described in more detail in Supplementary Material 1.

The aim of NetworkZ is to improve outcomes for surgical patients by improving teamwork and communication in operating theatre teams through embedding regular simulation-based multidisciplinary team training in New Zealand hospitals.

**Methods**

In this study we will address the following hypotheses and research questions.

**Primary Hypothesis**

Our primary hypothesis is that surgical patient outcomes will be improved following the implementation of NetworkZ as manifested in days alive and out of hospital over 90 days (DAOH\textsubscript{90}).

**Secondary hypotheses**

Our two secondary hypotheses are: (1) teamwork and communication processes will be improved and (2) the number and cost of ACC treatment injury claims will decline following the introduction of our training programme.

**Qualitative research questions**

We aim to: explore the factors that facilitate or impede implementation of NetworkZ; understand requirements for long-term sustainability; and identify
the types of changes occurring in the workplace following the implementation of NetworkZ.

Trial design

This is a mixed methods study, utilising quantitative and qualitative data in a stepped wedge, cluster randomised quality improvement design (see Figure 1). There are four cohorts of five DHBs each. Randomisation process: The 20 DHBs were divided into five groups of similar population size, calculated from publicly available Ministry of Health data on population sized served by each DHB. The first cohort comprised one DHB purposively selected from each of these five groups on the basis of capacity to start implementation. Following this initial selection, a random DHB from each size group was then selected for Cohort 2 and then for Cohort 3. The remaining DHBs comprised Cohort 4. In other words, one DHB from each size group was randomised to start the programme at the beginning of intervention period 2, period 3, and period 4 (Cohorts 2, 3 and 4).

[Figure 1 about here]

Comparison of outcomes will be undertaken between the pre-intervention period (control) starting one year before the first NetworkZ course in Cohort 1 DHBs, and the post-intervention period ending one year after the end of the transition period in Cohort 4. The transition period runs from the start of the DHB training for a Cohort, and lasts for 15 months, during which at least one third of staff in that Cohort should have attended a course. We believe that the effects from the intervention will not clearly manifest until at least 15 months, by which time a significant proportion of the staff will be trained and experienced with the intervention. No quantitative data will be collected during the transition period. We have chosen the stepped wedge cluster design
because it lends itself to a staged quality improvement project in which 
individual participants cannot be randomised to intervention or control.27 (see 
Figure 1)

Study population
There are two distinct populations included in the study protocol: the population 
of surgical patients and the population of surgical staff.

Patient population.
We will include patients undergoing surgery in public hospitals in New Zealand 
between February 1st 2016 and April 30th 2022 for patient outcome measures.
We will obtain outcome data for our primary hypothesis from the National 
Minimum Dataset (NMDS), a reliable administrative dataset collected by the 
New Zealand Ministry of Health. This data set provides a confidential and 
comprehensive record of all public hospital admissions and discharges in New 
Zealand, including demographics, ICD diagnoses, procedures, length of stay, 
and mortality associated with each admission. In 2017 the NMDS included 
330,353 cases of publicly funded surgery.28 The funding for NetworkZ allowed 
us to provide the team training for five major surgical specialities: general, 
orthopaedics, urology, otorhinolaryngology and plastics. 
For inclusion and exclusion criteria see Table 1.

<table>
<thead>
<tr>
<th>Study inclusion criteria</th>
<th>Study exclusion criteria</th>
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<td>Surgical patient admissions</td>
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Patient admissions that meet all of the following criteria:
- receive surgery in the five targeted surgical specialities
- receive surgical intervention involving a full surgical team
- requiring an overnight stay
- receive regional or general anaesthesia
- admitted for surgery to a publically funded hospital that has been, or will be, involved in the NetworkZ programme.

All subsequent readmissions to any hospital facility within the following 90 days will also be included.

Patient admissions that meet any of the following criteria:
- admitted and discharged on the day of surgery
- admitted to private hospitals
- receiving endoscopy using operator supervised sedation
- procedures requiring local infiltration only
- patients admitted to stand-alone paediatric hospitals.

Hospital staff

Public hospital staff working in one of the following roles:
- surgical specialists in the included five speciality groups
- anaesthetic specialists
- nursing staff working in operating theatres
- anaesthetic assistants (referred to as Anaesthetic Technicians in New Zealand)

Hospital staff working as:
- trainees in surgery or anaesthesia
- solely specialised paediatric hospital employees
- house surgeons (junior doctors not in specialist training programmes)
- health care assistants
- solely private hospital employees.

Patient sample size and power analysis

The sample will be all patients undergoing surgery in public hospitals during the study period who stay at least one night in hospital and are undergoing procedures in the included speciality groups. This number has been estimated from NMDS historical data to be in the order of 550,000 cases over the six-year study period.

Our sample size is primarily pragmatic. Both our design (i.e. stepped-wedge) and primary outcome variable (i.e. DAOH) present significant obstacles to
conventional sample size calculations. Nonetheless, we have undertaken an empirical power analysis on simulated data. We generated smooth sampling distributions from historical data for each DHB. This historic data feature the cohort structure of DHBs, and the within-DHB clustering of patients likely to be present in our future study data. We also generated versions of each distribution with a difference imposed at given quantiles by either flattening or accentuating the peaks in the data (i.e. a larger late peak means more patients with better DAOH). Using the recruitment parameters of our study, we generated 1,000 synthetic datasets with a simulated intervention effect. We compared the control and intervention groups using the Wilcoxon-Mann-Whitney U test, and assessed the significance of the calculated statistic by randomly permuting sites between cohorts 1,000 times, as in Thompson, et al. 29. Our simulations indicate a greater than 95% power at $\alpha=0.05$ to detect an intervention effect of one or more DAOH at the median, and two or more DAOH at the 0.25 quantile. We may apply quantile regression risk-adjustment to statistically evaluate differences of less than one DAOH (i.e. the minimum resolution of unadjusted DAOH data).

**Operating theatre staff population**

NetworkZ aims to train the majority of eligible staff working in the operating theatres of New Zealand public hospitals. Because there are four Cohorts with a staged annual roll out from 2017 to 2020 inclusive, the expected proportion of eligible operating theatre staff attending training over the study period are: 100% of Cohort 1; 75% of Cohort 2; 50% of Cohort 3; 25% of Cohort 4, and this is the basis of our sample size estimate. For surveys the unit of analysis will be the individual, while for observations, the unit of analysis will be the theatre team. See Table 1 for inclusion and exclusion criteria.
Total surgical staff population size

From specialist registration boards and hospital staffing lists we estimate the following: specialist surgeons \( \sim 730 \); specialist anaesthetists \( \sim 750 \); operating theatre nurses \( \sim 1800 \); anaesthetic technicians \( \sim 480 \). (Total = \( \sim 3,800 \) staff)

Operating theatre staff sample size estimate

For surveys, we will include all staff meeting the inclusion criteria. We will rate between 5 and 10 cases in each DHB in the three-month period prior to the introduction of NetworkZ in that DHB and immediately following the transition period in that DHB. Over the course of the study this will generate between 100 and 200 in the pre-NetworkZ period and a similar number in the post-NetworkZ period. Previous work indicates that fewer than 20 cases before and 20 after an intervention can detect a difference of one point on the seven-point WHOBARS scale\(^{30}\) in 80% of cases. We are undertaking more observations to obtain a representative sample across DHBs.

Outcome measures

Primary outcome measure (addressing primary hypothesis)

The primary outcome measure for the study is Days Alive and out of Hospital after 90 days (DAOH\(_{90}\)), recently validated for the surgical context.\(^{31}\) DAOH provides a holistic approach to measuring patient harm that incorporates mortality and length of time out of hospital for a defined number of days (in this case 90 days) following an index event (in this case, a surgical procedure).\(^{32}\) Days in hospital include those until discharge following surgery, and those during any readmissions to public hospitals within the specified 90-day postoperative period. DAOH\(_{90}\) scores will be affected by mortality and any complications that either prolong hospitalisation or result in readmission.
DAOH<sub>90</sub> score will be zero for patients who die without ever leaving hospital, but any day alive and out of hospital during the 90-day period will be counted. Index procedures for DAOH<sub>90</sub> will be limited to patients who stay in hospital for at least one night. The rationale for this is to restrict the patient population to those at higher risk of adverse events, and to increase the likelihood that when a patient is admitted for a diagnostic procedure prior to definitive surgery, the 90-day period begins with this definitive surgery. A surgical admission within 90 days will be subtracted from the 90 days when calculating DAOH<sub>90</sub>. Additionally, we will explore the influence of the proportion of staff in each DHB who have attended a NetworkZ course. In a secondary analysis we will also calculate Days out of Hospital and Mortality separately to tease out the individual effects of these on the primary outcome. The analysis will follow the procedure for the analysis of the primary outcome measure.

**Statistical analysis**

Using the Stepped Wedge cluster design we will analyse the differences between pre- and post-NetworkZ cohorts on each of the patient outcome measures. Data will be classified into pre-NetworkZ (control), transition, and post-intervention intervention categories (see Figure 1). Due to the highly skewed and bimodal nature of the DAOH<sub>90</sub> scores (see Figure 2), we will use the non-parametric Wilcoxon-Mann-Whitney rank sum test as our primary test to derive a statistic for the overall difference between distributions before and after implementation of NetworkZ. To assess the significance of the difference, we will compare the statistic to the values derived from 10,000 random permutations of cluster (i.e. DHB) to sequences (i.e. cohorts). The permutation test does not vary the timing of an individual patient’s admission,
rather an individual patient will be permuted with all other patients in their cohort, as they will be assigned to the intervention based on the interplay between their actual time and the cohort sequence to which they are permuted. Thus, the null distribution of the Mann Whitney U test will account for any overall temporal effects within the dataset.

We will then perform quantile regression at the 0.1, 0.25, 0.75, 0.9 quantile to characterize any difference between the two distributions. This quantile regression will include time (month and year of procedure) in order to adjust for time effects, cohort, DHB (within cohort) and intervention as factors in the model. To assess the impact of the purposive sampling of Cohort 1 DHBs, we will conduct a sensitivity analysis by re-running the above analysis using Cohort 2, 3, and 4 data.

[Figure 2 about here]

Secondary outcome measures (addressing secondary hypotheses)

Teamwork Perceptions Survey

The Teamwork Perceptions Survey was designed to align with the intended learning outcomes of NetworkZ (Supplementary material 2). Items were drawn from behaviours of effective teams described by Salas and refined through review and consensus with an expert group. The survey will be administered to all operating theatre staff who are regularly working in operating theatres in the specialities targeted by the course.

This survey will be administered in the 3-month period prior to a DHB commencing training and repeated at the end of the transition period (at 15 months). Staff in DHBs around the country will be assigned unique confidential identifiers. These identifiers will be used in the surveys to enable matching of
participants' pre- and post- intervention survey responses and determine if they have participated in NetworkZ.

Analysis

Pre- and post-Teamwork Perceptions Survey total scores and subscale scores will be assessed using a Generalized Linear Mixed Model (GLMM). The analysis will include terms for cohort, DHB (random effect nested within cohort), intervention, month and year, with the primary comparison using the cohort as the replicate of the intervention effects. Small sample correlations will be considered. Additionally, we will explore the influence of the proportion of staff in each DHB who have been trained.

Surgical Safety Culture Survey (SCCS)
The SSCS measures attitudes and behaviours relevant to surgical safety and survey scores have been shown to predict 30-day risk of post-operative death. The Health Quality and Safety Commission (HQSC) has made minor changes to the survey terminology for the New Zealand context. HQSC administers this national survey to all operating theatre staff on a bi-annual basis. The survey is anonymous but includes demographics such as DHB and professional role. HQSC administered the survey in February 2017 with subsequent administrations planned for February 2019 and February 2021.

Analysis

Pre- and post-SCSS total scores and subscale scores will be assessed using a GLMM. The analysis will include terms for cohort, DHB (random effect nested within cohort), intervention, month and year, with the primary comparison using the cohort as the replicate of the intervention effects. Small sample correlations will be considered.
Observations of WHO Surgical Safety Checklist administration

We will utilise the World Health Organisation Behaviourally Anchored Rating Scale (WHOBARS) observation tool previously developed and validated by members of our research group\textsuperscript{30, 35} (see Supplementary material 3). WHOBARS measures the quality of administration of the Surgical Safety Checklist (SSC). The SSC is used almost universally in New Zealand and provides a standardised opportunity to share important information with other members of the surgical team. Changes in teamwork and communication should be reflected in this measure. Case selection for the WHOBARS observations will be a convenience sample of available cases over a 3-day rating period in each DHB and will include any surgical case that falls within the eligibility criteria for NetworkZ. We will record unique staff identifiers for each team observed to enable post-NetworkZ influence of the number and role of staff in a team who have participated in a NetworkZ course. In order to generate reliable scores we will train raters using a series of videos and actual theatre cases.

Analysis

The analysis will compare mean and subscale WHOBARS scores for surgical teams pre- and post- the NetworkZ intervention using a GLMM. The analysis will include terms for cohort, DHB (random effect nested within cohort), intervention, month and year, with the primary comparison using the cohort as the replicate of the intervention effects. Small sample correlations will be considered. We will also undertake an exploratory analysis to investigate if the proportion of staff trained moderates the difference between pre- and post-training.
Number and costs of ACC treatment injury claims

To provide an indication of the fiscal outcomes of the intervention, surgical treatment injury claims submitted to ACC will be analysed using claims that are relevant to the surgical specialties targeted by NetworkZ. We will exclude claims that relate to specialties not included in NetworkZ. We will analyse ACC data using the same patient population groups over the same time-periods as established for the stepped wedge design for the primary analysis. The analysis will compare claim data pre- and post- the NetworkZ implementation using a GLMM. The analysis will include terms for cohort, DHB (random effect nested within cohort), intervention, month and year, with the primary comparison using the cohort as the replicate of the NetworkZ effects. Small sample correlations will be considered. We will conduct separate analyses for the number and cost of claims.

Post-operative complications captured in the NMDS

To provide secondary data around patient safety, we intend to examine post-operative complications available in the NMDS. The NMDS captures information about new diagnoses that emerged as a result of surgical complications and instances of medical misadventures during surgery that have been captured in medical notes. This data will be analysed using the same patient population groups over the same time periods as the primary analysis.

Sick leave records

Improved teamwork has the potential to reduce staff retention and the use of sick-leave. We will assess monthly OR staff time off from illness by DHB to assess if there are reductions in sick leave following introduction to the programme.
Qualitative measures (addressing qualitative research questions)

We will undertake interviews with each Cohort to address the three qualitative research questions. We will conduct semi-structured interviews with DHB staff involved in NetworkZ on the project team or as instructors. We will identify potential participants through the NetworkZ database and sampling will be purposive to include a range of views from large and small DHBs, from different professional groups, and those with different roles. Sampling will continue to the point of data sufficiency, when no new themes are emerging and existing themes are sufficiently described. We anticipate a sample size of 20-30 interviews per Cohort. Timing of interviews will be during the transition period, during the period of implementation of NetworkZ. Interviews will be transcribed and coded using NVivo prior to framework analysis or general thematic analysis.

Patient and public involvement

There was no patient or public involvement in the development of this study protocol.

Ethics and dissemination

This study has been approved by the New Zealand Health and Disability Ethic Committee (HDEC) (#16/NTB/143). The committee waived the requirement for individual patient consent.

The protocol was registered with the Australian and New Zealand Clinical Trials Registry (ANZCTR) on 5th January 2017 and last updated on 7 August 2018.
protocol title is “Evaluation of NetworkZ: Can multidisciplinary team-training improve the safety of surgery in New Zealand?” The Trial ID is ACTRN12617000017325 and the Universal Trial Number is U1111-1189-3992.

Discussion

NetworkZ is a nationwide response to the global need to improve the safety of surgical care. To our knowledge this will be the first occasion when a surgical team training initiative has been implemented on a national scale. Access to routinely collected health data at a national scale is key to the feasibility of our evaluation.

The unique features of NetworkZ team training include: interactive surgical models integrated with computerised full-body computerised manikins that allow all members of the surgical team to participate; in situ training using real teams in real operating theatres; providing simulation resources and instructor training to build local capacity to independently run the course.

Strengths of the study

This is a national study, involving multiple sites and large numbers. It is adequately powered to show a difference in DAOH if one exists. Access to high-quality data routinely-collected nationally on hospital events is a major strength, without which the study would not be feasible.

Our primary outcome measure, DAOH, is a relatively new measure for surgical patient outcomes, recently validated for the surgical context.\(^{31}\) DAOH\(_{90}\), provides a holistic evaluation of surgical outcomes that is sensitive to any cause of death, prolonged hospital stay or readmission. This measure can be reliably and cost-effectively derived from the data in the NMDS and is objective.
Stepped wedge cluster design is very suitable for quality improvement initiatives in which it is impossible (or at least highly impracticable) to randomise individual cases or participants.\textsuperscript{27,36} It is uniquely suited to initiatives that are rolled out over time.

Another strength of our study is the mixed methods approach. The secondary outcome measures and qualitative data can provide supporting evidence of change attributed to NetworkZ and provide complementary insights into whether the programme is working as intended and why the programme is or is not working.

\textit{Weaknesses of the study}

Team training interventions may take time to have an effect and we may thus fail to detect an effect due to sampling too early. Due to the limited timeframe for implementation of training in the initial Cohort as dictated by our funding contract, Cohort 1 DHBs were not selected randomly, but were purposively selected as we had an existing relationship with those DHBs. There are anticipated limitations of exploring the effect of quality improvement initiatives in the real world, including implications for standardisation, randomisation and control groups. For example implementation of training depends on the willingness of DHBs to support NetworkZ, local staff to undertake the Instructor Training, and DHB staff to attend the courses.

Despite numerous measures to achieve consistent, high quality training, there are challenges in achieving standardisation of NetworkZ delivery in individual DHBs where the local staff take on the responsibility for implementing the program in their own environments.

Due to the potential for other factors progressively influencing patient outcomes over time, we will not be able to prove that the changes can be attributed to
NetworkZ. This will be mitigated to some extent through the stepped wedge design and triangulation with measures of teamwork through surveys and observations.

**Conclusion**

With the financial support of our publicly funded Accident Compensation Corporation, the unique opportunity exists to implement and evaluate a nationwide team-training initiative for full operating theatre teams in all public hospitals in New Zealand. By using a pre-existing large administrative data set, we have the potential to demonstrate a difference to surgical patient outcomes from this quality improvement team-training initiative.

**Acknowledgements**

The authors would like to express special gratitude to Kaylene Henderson, Jane Torrie, Richard Hamblin and Ian Civil for their tireless efforts in the development and delivery of the NetworkZ programme, and the ongoing support of its evaluation.

**Data statement**

At the conclusion of the study de-identified Teamwork Perceptions Survey data will be available on reasonable request from cmhseadmin@auckland.ac.nz, for a period of five years for academic purposes. Other data that will be utilised in this study either cannot be adequately de-identified or was obtained from third-party databases that the authors do not have authority to grant access to.
Conflict of interest statement

Dr. Merry is Chair of the Health Quality and Safety Commission NZ and a director of SaferSleep LLC. Both Dr Merry and Dr Webster hold shares in SaferSleep LLC.

Funding

This delivery and evaluation of NetworkZ is funded by the Accident Compensation Corporation of New Zealand, and supported by grants from the Australian and New Zealand College of Anaesthetists (2017 Douglas Joseph Professorship Grant, Project Number DJ17/001), and the Lottery Health Research Fund (Project Number: R-LHR-2017-49141).

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References


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Figure 1. The stepped-wedge cluster cohort design.

Figure 2. Probability density graph for the distribution of DAOH based on historical data from 2011-07-01 to 2016-06-30 (blue dotted) and the same with a simulated
difference of one day imposed at the median (red solid). Note square root transform on y-axis.
**Cohort 1**
Begins Feb 2017

**Cohort 2**
Begins Feb 2018

**Cohort 3**
Begins Feb 2019

**Cohort 4**
Begins Feb 2020

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**Key:**
- Pre-NetworkZ (Control) period
- Transition period (15 months)
- Post-NetworkZ period

Measurement begins 1 February 2016

Measurement ends 30 April 2022
Supplementary material 1

The NetworkZ programme and implementation process

The NetworkZ course

The NetworkZ course full-day course comprising simulated scenarios, debriefs, presentations and group discussion the full-day NetworkZ course can be delivered as two half-day courses in order to minimise operational disruption and thus maximise acceptability. The long-term aim is for all operating theatre staff in New Zealand public hospitals to complete a full day of training at least every three years. The course is designed for the five surgical specialties with the largest number of surgeons: general, orthopaedics, otorhinolaryngology, urology and plastics. Obstetrics and gynaecology for which a simulation training programme (non-OR) already existed was not included.

Scenarios:

When implementation has been completed 25 simulated scenarios will have been developed from actual cases of co-morbid patients presenting for surgery with a range of conditions such as trauma, sepsis, abdominal and post-operative airway emergencies. Simulated scenarios last between 25 and 45 minutes and the scenarios are designed to be challenging and complex with multiple decision points for the entire team. Scenarios begin prior to induction of anaesthesia and include detailed case notes, supporting documentation, imaging and investigations. They take place in each team’s actual operating theatre using available anaesthetic and surgical equipment, drugs and fluids and other consumable items, with formalised strategies to manage known risks of in-situ simulation. The simulations use the Laerdal 3G SimMan manikins with moulage and custom built face masks and body suits, combined with surgical models to maximise fidelity, to convey different simulated patients and to provide appropriate surgical, anaesthetic and nursing tasks. Examples of the surgical models include a ruptured appendix, a traumatic leg amputation and, and a neck haematoma compromising the airway. The models permit surgical interventions including incision, haemorrhage...
control, suturing, resection, and anastomosis. The manikin is pre-programmed to convey patient status at various phases of the scenario with supervisory control to respond to unexpected participant actions. A full surgical team participates in each scenario including at least one specialist surgeon and one specialist anaesthetist, three theatre nurses and an anaesthetic assistant. Surgical and anaesthesia trainees often participate as do health care assistants and post-anaesthetic care unit nurses.

NetworkZ faculty observe from behind a partition, screen or via video-link (depending on local facilities). Faculty control the manikin and surgical models in response to participant actions and answer participant phone calls for assistance or advice following scripts which replicate local processes. The scenarios are not recorded and there are no participant observers.

Participants are supported by a ‘confederate’ nurse or anaesthetic assistant who is in communication with the instructional team. The confederate assists with clinical tasks in the simulated environment such as taking blood samples or by discreet communication of physical signs unable to be replicated by the manikin or models (e.g. deviated trachea).

Debriefing:

The scenario is followed by a facilitated debrief with 2 trained NetworkZ instructors using three distinct phases: Phase 1 participant reactions; Phase 2 description, analysis, application; Phase 3 personal transfer to practice. Questioning approaches emphasise open questions and advocacy enquiry.(39, 40) Debriefers refer to specific communication tools and teamwork behaviours from the Salas model(24) with the aid of wall-mounted posters. Systems issues identified in the debrief are recorded and reported back to the local quality improvement leader for follow up.

Interactive Presentations:

Purpose-designed trigger videos and animations are used to emphasise communication strategies and specific tools for briefing the team. The strategies and tools include ISBAR, closed loop communication, speaking up, and structured recapping. Participants are encouraged to explore their
different professional roles, perspectives and assumptions to develop strategies to work together more effectively.

**NetworkZ instructor training**

The NetworkZ course quality is assured by the requirement for instructors to demonstrate competency in ten domains of practice, using Entrustable Professional Activities (EPAs) as an organising framework for the curriculum. These domains are: fundamentals of effective teamwork; creating a safe learning environment; conducting a scenario; identifying learning points while observing a scenario; conducting a debrief; evaluating learning; managing risk with in situ simulation; preparing the clinical environment for simulation, operating the simulation equipment; and maintaining simulation resources.

The EPAs are mastered using a blended approach to course delivery that includes face-to-face workshops, online learning and apprentice-ship style learning with observation and feedback from senior faculty. Instructor assessment includes online submissions and assessment of performance.

**Implementation strategy**

Our approach to implementation is multifaceted, incorporating multiple stakeholders; national bodies included central committees of the 20 New Zealand District Health Board (DHB) executives, the Royal Australasian College of Surgeons, the Australian and New Zealand College of Anaesthetists; New Zealand Nursing Council; and Institute of Anaesthetic Technicians. Approximately 12 months prior to the introduction of NetworkZ, the NetworkZ project team meet the DHB senior executive team, and negotiate a formal letter of agreement with the Chief Executive. This outlines the gift of a 3G Laerdal simulator and some surgical models to the DHB, provision of training and support by the NetworkZ project team and the expectations of DHB support for release of staff to attend training with provision of the training venue. In each DHB local project teams are established with connections to senior executive and quality assurance leads. A local group of instructors are nominated and undertake training. NetworkZ training in the DHB is initially supported by UOA faculty but gradually devolved
to local DHB instructors as they complete NetworkZ instructor training. After 12 to 15 months, DHBs assume full responsibility for running the NetworkZ course in their DHB. UOA maintains a role in quality improvement, quality monitoring, instructor training and course development.
Teamwork Perceptions Survey

Please rate the following components of teamwork in the operating theatre teams where you regularly work. We acknowledge that your experiences will vary between different theatre teams. Please try to give an average rating for your experiences of teamwork across the theatres where you regularly work, rather than rating one specific theatre team.

Please note this is about the whole theatre team, including surgeons, nurses, techs and anaesthetists.

SA = Strongly Agree; A=Agree; N=Neutral; D=Disagree; SD=Strongly Disagree

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<tr>
<td><strong>In general, in theatres where I regularly work, senior staff</strong> (e.g. consultant surgeon and anaesthetist, senior nurse, charge tech):</td>
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<td>1. Provide clear directions to the team</td>
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<td>2. Use an appropriate balance of assertiveness and support</td>
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<td>3. Motivate team members to do their best</td>
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<td>4. Establish a positive atmosphere in theatre</td>
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<td>5. Facilitate team problem solving during the case</td>
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<td>6. Role model acceptable interaction with colleagues</td>
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<td>7. Engage in pre case briefings of the whole team</td>
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<td>8. Co-ordinate tasks and individual team member contributions to patient care</td>
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<td><strong>Team members:</strong></td>
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<td>9. Provide support to each other</td>
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<td>10. Shift work responsibilities to underutilised team members at times of high workload</td>
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<td>11. Keep an eye on other team members’ performance</td>
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<td>12. Speak up about potential mistakes or lapses in other team members’ plans or actions</td>
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<td>13. Provide constructive feedback regarding team member actions to facilitate self-correction</td>
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<td>14. Are willing to acknowledge mistakes and accept feedback</td>
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<td>15. Value the input of all team members to patient care</td>
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<td>16. Take into account alternative solutions offered by other team members</td>
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17. Share information about the case planning, progress and concerns with other team members

18. Involve the whole team in planning patient care

19. Have a good understanding of the roles and abilities of their teammates

20. Anticipate and predict each other’s needs

21. Have a lot of respect for each other

22. Enjoy working together

23. Exchange information clearly and concisely

24. Use names frequently when communicating information or allocating tasks

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<tr>
<th>Global rating</th>
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<tr>
<td>25. Overall, the theatre teams I work in demonstrate effective teamwork and communication behaviours</td>
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**Comments**

Which hospital are you completing this survey for? _____________________________

What is your role in the operating theatre? (Please tick one)

- Consultant surgeon
- Consultant anaesthetist
- Anaesthetic technician
- Other (please specify) ______________
- Surgical registrar/fellow
- Anaesthetic registrar/fellow
- Theatre nurse

Male □    Female □

Which of the following best describes your ethnicity? (Please tick one)

- New Zealand European
- Pacific Peoples
- Asian Indian
- Other (please specify) ______________
- Māori
- Asian
- Other European

Thank you for taking the time to complete this survey
### 1. Setting the Stage

The Checklist is initiated appropriately.

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<th>Excellent</th>
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**Examples**
- Checklist reader starts reading out Checklist items without establishing readiness of participants.
- Sign In is begun while one or more of the team are doing other things (e.g., the anaesthetist is inserting a line).
- Sign In starts by the Checklist initiator raising his or her voice rather than establishing readiness.
- Sign In is begun after the induction of anaesthesia.

**Comments:**

### 2. Team Engagement

All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

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<th>Excellent</th>
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**Examples**
- Anaesthetist says something unsupportive like “How long is this going to take? I need to get on with some real work.”
- A key team member is absent from the room during Sign In (e.g., the anaesthetist).
- Anaesthetist and/or nurse continue doing their work, attempting to multi-task.
- Any person in the room conducting conversations, speaking on the phone, hooking up equipment, and so on instead of concentrating on the Sign In.

**Comments:**

### 3. Communication: Activation

Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

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**Examples**
- No names are used.
- Speaking softly indicating a private rather than shared conversation.
- Senior team member makes a derogatory remark when someone asks a safety-related question or points out an important fact.

**Comments:**

**Examples**
- The Checklist initiator says something like “Is everyone able to take a couple of minutes for the Checklist?” or (to an individual) “Are you free to do the Sign In now or should we wait a minute or two?”
- The anaesthetist says something like “I just need to finish this—can we wait a couple of minutes please?” The Checklist reader then waits until the anaesthetist is ready.
- Sign In is begun when patient first enters room before any drugs are administered.

**Comments:**
4. Communication: Problem  
Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

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**Examples**

**PATIENT INFORMATION**
- The nurse reminds the team that the patient is allergic to several drugs after the induction drugs have been administered.

**EXPRESSED CONCERN**
- Uncertainty is expressed about the potential for blood loss, but no one speaks with the surgeon to check.
- Anaesthetist pays no attention and fails to respond to the question even by saying something like “I have no concerns.”
- Surgeon says something like “There is no time for this—people should know what to expect.”
- The anaesthetist says that there is a potential difficulty with intubation but is not provided adequate assistance or support or time to deal with this problem.

**Comments:**

5. Communication: Process  
Completion  

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

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**Examples**

**PROCESSES & PROCEDURES**
- Anaesthetist fails to acknowledge one or more of the questions about airway, the readiness of anaesthetic machine, blood loss, etc.
- All of the team state that side is correct without anyone checking surgical site marking.

**Comments:**
### 1. Setting the Stage

**WHOBARS: TIME OUT [S]**

**The Checklist is initiated appropriately.**

<table>
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<tbody>
<tr>
<td><strong>ESTABLISHING READINESS</strong></td>
<td></td>
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<tr>
<td>• The Checklist reader starts reading out Checklist items without establishing readiness of participants.</td>
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<tr>
<td>• Time Out is begun while one or more of the team are doing other things (e.g., assembling the sterile field, assessing anaesthesia).</td>
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<tr>
<td>• Time Out is initiated after the first surgical incision.</td>
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<tr>
<td><strong>MANNER</strong></td>
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<tr>
<td>• Checklist is read quickly and the answers are assumed without pausing to check that the surgeon and anaesthetist agree with the answers.</td>
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<td><strong>Comments:</strong></td>
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<tr>
<td><strong>ESTABLISHING READINESS</strong></td>
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<tr>
<td>• The Checklist initiator says something like “Is everyone able to take a couple of minutes for the Checklist?” or (to an individual) “Are you free to do the Time Out now or should we wait a minute or two?”</td>
<td></td>
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<tr>
<td>• The Checklist initiator says something like “Can we do the Time Out now, please? Is everyone ready to take part?”</td>
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<tr>
<td>• Time Out is called at the end of prepping and draping, prior to surgical incision.</td>
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<td><strong>MANNER</strong></td>
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<tr>
<td>• The Checklist initiator thanks people for their input or acknowledges input in a positive way (i.e., eye contact, a friendly nod).</td>
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<tr>
<td>• The Checklist reader uses an assertive tone of voice conveying a commitment to the Checklist process.</td>
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### 2. Team Engagement

**All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.**

<table>
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<tbody>
<tr>
<td><strong>SUPPORTIVE</strong></td>
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<tr>
<td>• Someone says something like “This is a waste of time.”</td>
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<tr>
<td><strong>ENGAGEMENT</strong></td>
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<tr>
<td>• Key members talk on the phone or to each other during Time Out.</td>
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<td>• The surgeon says something like “Let’s get on with the checklist,” but then walks out of the room while it is being administered.</td>
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<td>• Key members continue with preoperative tasks during the Checklist, attempting to multi-task.</td>
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<td>• The registrar occupies self with other activities instead of paying attention.</td>
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<td><strong>Comments:</strong></td>
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<tbody>
<tr>
<td><strong>SUPPORTIVE</strong></td>
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<tr>
<td>• Surgeon or anaesthetist says something like “Thank you, Jane [to checklist reader]. Could everyone pay attention please? This is important.”</td>
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<td><strong>ENGAGEMENT</strong></td>
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<tr>
<td>• All team members stop other activities and concentrate on the Checklist.</td>
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<tr>
<td>• Someone asks a question about something that he or she did not understand.</td>
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<tr>
<td>• Anaesthetist refers to patient chart to verify critical patient information as it is read out.</td>
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### 3. Communication: Activation

**Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.**

<table>
<thead>
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<tbody>
<tr>
<td><strong>COMMUNICATION</strong></td>
<td></td>
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<tr>
<td>• Some team members state name but not role during introductions.</td>
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<tr>
<td>• Communication during the Checklist process is undirected, even by body language, and people speak to “thin air” rather than to each other.</td>
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<tr>
<td><strong>INCLUSIVENESS</strong></td>
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<tr>
<td>• Senior team member makes a derogatory remark when someone asks a question they might have been expected to know the answer to.</td>
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<tr>
<td>• Observers such as students are ignored and not introduced.</td>
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<tr>
<td>• A negative remark is made about someone raising a patient safety concern.</td>
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<td><strong>Comments:</strong></td>
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<tbody>
<tr>
<td><strong>COMMUNICATION</strong></td>
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<tr>
<td>• Every OR team member clearly states name and role during introductions.</td>
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<tr>
<td>• The Checklist reader confirms that everyone knows each other, perhaps because introductions occurred in a previous case.</td>
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<tr>
<td><strong>INCLUSIVENESS</strong></td>
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<tr>
<td>• Every person in the OR is acknowledged during the introductions.</td>
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<tr>
<td>• Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.</td>
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<td>• Circulating nurse is given opportunity to view consent form prior to first incision and confirms it aloud to all team members.</td>
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<tr>
<td>• Observers such as students are introduced.</td>
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For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml
4. Communication: Problem

**Anticipation**

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

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**Examples**

- **PATIENT INFORMATION**
  - Procedure is not delayed although an item of potentially important information is missing.
  - The surgeon indicates a potential for considerable bleeding, but the anaesthetist, who inserted a small IV line, does not respond by supplementing this.
  - Surgeon says something like "Can we just get on with the procedure please—people should know what to expect."

- **EXPRESSED CONCERN**
  - Patient information
  - Surgeon says something like "This patient has ischemic heart disease so I am worried about a myocardial infarction."
  - Surgeon says something like "OK, just a 'heads up.' This patient’s tissues are likely to be really poor, and I think I might have real problems with bleeding around the aorta."
  - Willingness is shown to delay procedure to get information needed.

**Comments:**

5. Communication: Process

**Completion**

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**Examples**

- **PROCESSES & PROCEDURES**
  - Anaesthetist says something like "Oh thanks—just giving the antibiotic now," but surgeon says something grumpy and proceeds to make incision anyway, without waiting for this to happen (i.e., he ignores the message).
  - The Checklist reader asks "Has antibiotic been given within last 60 minutes?" There is no response, but reader carries on with Checklist regardless.
  - All of the team state that side is correct without anyone checking surgical site marking.

- **EXPRESSED CONCERN**
  - Surgeon says something like "This should be routine today—I have no concerns."
  - Surgeon confirms the procedure will be done and indicates whether there is anything out of the ordinary about this case.
  - Surgeon confirms with nursing team that any necessary special equipment or supplies are available before patient is induced.
  - Surgeon states, "I would not expect a transfusion to be needed for this procedure. Can you please inform me if we get to a situation where you think this is indicated?"
  - Surgeon and anaesthetist check key blood products are available.
  - Patient's identification is re-checked and verified.

**Comments:**
WHOBARS: SIGN OUT [N]

1. Setting the Stage

The Checklist is initiated appropriately.

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**ESTABLISHING READINESS**
- Sign Out is done after surgeon has left the room or has left the table and is trying to do something else like write the operation note.
- The Checklist reader starts reading out checklist items without establishing readiness of participants.
- Sign Out is performed when all team members are present, but during the transfer of the patient from table to bed, i.e. with no "pause."

**MANNER**
- Checklist reader uses tone of voice that suggests apathy, disinterest or disdain for the checklist process.

**Examples**

**Establishing Readiness**
- The Checklist initiator says something like "Can we do the Sign Out now, please? Is everyone ready to take part?"
- Sign Out is initiated as skin is being closed with all team members present and able to participate.

**Manner**
- Checklist initiator says something suggesting personal interest or commitment to the checklist, e.g., "listen up folks, checklist time," in a tone of voice that suggests all have to pay attention.

Comments:

2. Team Engagement

All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

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**ENGAGEMENT**
- Surgeon has already left theatre.
- Surgeon says "You guys take care of this" and walks out.
- Scrub nurse continues to tidy instruments and ignores process.
- Anaesthetist and/or nurse continue doing their work, attempting to multi-task.

**SUPPORTIVE**
- The surgeon says something like "I am going to let the resident close. Would it be OK to do the sign out now and then I can go and see the next patient while the rest of you finish off?"
- All team members stop other activities and concentrate on the Checklist.
- Scrub nurse stops all other activity and says something like "Are we all sure this patient’s coags are okay? He still looks pretty wet to me."
- Anyone asks a question about some aspect of the patient’s care.

**Examples**

**Engagement**
- Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.
- Nurse indicates swab count is not correct and receives a critical or unsupportive response.
- The swab count indicates a missing swab, and the surgeon says something like “Thanks—we had better have another look behind the heart.”

Comments:

3. Communication: Activation

Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

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**INCLUSIVENESS**
- Senior team member makes a derogatory remark when someone asks a question they might have been expected to know the answer to.
- During Sign Out, the anaesthetist indicates the need for additional time to ensure patient is safe but receives an unsupportive response.
- Nurse indicates swab count is not correct and receives a critical or unsupportive response.

**Examples**

**Inclusiveness**
- Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.
- Nurse indicates swab count is not correct, and surgeon thanks him or her for helping to avoid a problem.
- The swab count indicates a missing swab, and the surgeon says something like “Thanks—we had better have another look behind the heart.”

Comments:
WHOBARS: SIGN OUT

5. Communication: Process Completion

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Examples

- **EXPRESSION CONCERN**
  - Team member speaks up about potential difficulty with equipment for the next procedure and receives an unsupportive or critical comment from the surgeon.
  - Information about a potential problem is ignored.
  - Anaesthetist comments to scrub nurse, after surgeon has left, something like “I was a bit worried about patient’s post op pain management because epidural wasn’t working, but I didn’t want to bother the surgeon.”

- **PATIENT INFORMATION**
  - Surgeon says to resident who will be writing orders, “Remember that this patient has an epidural, so our anticoagulation can only be unfractionated subcutaneous heparin until after the epidural is removed.”
  - Surgeon says to anaesthetist, “This patient may have significant pain problems, so a dose of ketorolac now might be helpful for early postoperative pain relief.”

- **EXPRESSED CONCERN**
  - Anaesthetist verbally discusses immediate and early post-operative measures to ensure patient safety.
  - Surgeon verbally hands over instructions relating to drain outputs and early post-operative care.
  - Specific elements of postoperative care are reviewed such as need for anticoagulants, postop antibiotics yes/no, pain management plans, need for special monitoring, etc.
  - Surgeon says something like “I am worried this patient is oozing. John [to the anaesthetist] could you ask the ward to organize a coagulation screen please?”
  - Anaesthetist says something like “Thanks. I really appreciate the opportunity to discuss this patient’s poor respiratory reserve—I think he might get into trouble overnight.”

Comments:

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4. Communication: Problem Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

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Examples

- **EXPRESSIONS CONCERN**
  - Specimen is (or has been) sent off without checking label.
  - The swab count shows a missing swab, and the surgeon says something like “You guys can’t count” and proceeds to close anyway.
  - Nurse indicates that swab count is correct, but there is no response to confirm that the surgeon has heard.

- **PATIENT INFORMATION**
  - Surgeon says to resident who will be writing orders, “Remember that this patient has an epidural, so our anticoagulation can only be unfractionated subcutaneous heparin until after the epidural is removed.”
  - Surgeon says to anaesthetist, “This patient may have significant pain problems, so a dose of ketorolac now might be helpful for early postoperative pain relief.”

- **EXPRESSED CONCERN**
  - Anaesthetist verbally discusses immediate and early post-operative measures to ensure patient safety.
  - Surgeon verbally hands over instructions relating to drain outputs and early post-operative care.
  - Specific elements of postoperative care are reviewed such as need for anticoagulants, postop antibiotics yes/no, pain management plans, need for special monitoring, etc.
  - Surgeon says something like “I am worried this patient is oozing. John [to the anaesthetist] could you ask the ward to organize a coagulation screen please?”
  - Anaesthetist says something like “Thanks. I really appreciate the opportunity to discuss this patient’s poor respiratory reserve—I think he might get into trouble overnight.”

Comments:
**Evaluation of the effect of multidisciplinary simulation-based team training on patients, staff and organisations:** protocol for a stepped-wedge cluster mixed methods study of a national, insurer-funded initiative for surgical teams in New Zealand public hospitals.

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<td>Date Submitted by the Author:</td>
<td>15-Jan-2020</td>
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<td>Complete List of Authors:</td>
<td>Weller, Jennifer; The University of Auckland, Centre for Medical and Health Sciences Education Long, Jennifer; The University of Auckland, Centre for Medical and Health Sciences Education Beaver, Peter; The University of Auckland, Centre for Medical and Health Sciences Education Cumin, David; The University of Auckland, Department of Anaesthesiology Frampton, Chris; University of Otago, Department of Medicine, Christchurch School of Medicine and Health Sciences Garden, A. L.; Wellington Hospital, Anaesthesia; Victoria University of Wellington, School of Biological Sciences Moore, Matthew; The University of Auckland, School of Medicine Management Webster, Craig; The University of Auckland, Centre for Medical and Health Sciences Education; The University of Auckland, Department of Anaesthesiology Merry, Alan; The University of Auckland, Department of Anaesthesiology</td>
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Title

Evaluation of the effect of multidisciplinary simulation-based team training on patients, staff and organisations: protocol for a stepped-wedge cluster mixed methods study of a national, insurer-funded initiative for surgical teams in New Zealand public hospitals.

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Author contributions
JMW and AFM conceived the original proposal and drafted the original manuscript. JMW, AFM, JAL, PB, DC, CF, ALG, MRM, CSW contributed to the development and refinement and statistical analysis of the protocol. All authors critically appraised the drafted manuscript and made important intellectual contributions to the writing. All authors read and approved the final submitted manuscript.

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Abstract

Introduction

NetworkZ is a national, insurer-funded multidisciplinary simulation-based team-training programme for all New Zealand surgical teams. NetworkZ is delivered in situ, utilising full-body commercial simulators integrated with bespoke surgical models. Rolled out nationally over four years, the program builds local capacity through instructor training and provision of simulation resources. We aim to improve surgical patient outcomes by improving teamwork through regular simulation-based multidisciplinary training in all New Zealand hospitals.

Methods and analysis

Our primary hypothesis is that surgical patient outcomes will improve following NetworkZ. Our secondary hypotheses are that teamwork processes will improve, and treatment injury claims will decline. In addition, we will explore factors that influence implementation and sustainability of NetworkZ and identify organisational changes following its introduction.

The study utilises a stepped-wedge cluster design. The intervention will roll out at yearly intervals to four cohorts of five District Health Boards (DHB). Allocation to cohort was purposive for year 1, and subsequently randomised. The primary outcome measure is Days Alive and Out of Hospital at 90 days using patient data from an existing national administrative database.

Secondary outcomes measures will include analysis of post-operative complications and treatment injury claims, surveys of teamwork and safety culture, in-theatre observations, and stakeholder interviews.

Ethics and dissemination
We believe this is the first surgical team training intervention to be implemented on a national scale, and a unique opportunity to evaluate a nation-wide team-training intervention for healthcare teams. By using a pre-existing large administrative data set, we have the potential to demonstrate a difference to surgical patient outcomes. This will be of interest to those working in the field of healthcare teamwork, quality improvement and patient safety.

New Zealand Health and Disability Ethic Committee approval (#16/NTB/143). Australian and New Zealand Clinical Trials Registry ID ACTRN12617000017325.

**Article summary**

**Strengths and limitations of this study**

1. The study uses a mixed methods approach to test the effectiveness of the NetworkZ training intervention in the context of real-world implementation across an entire nation.

2. Our primary outcomes measure, Days Alive and Out of Hospital at 90 Days, is an holistic measure of surgical outcomes utilising routinely collected health data from a national administrative database.

3. Programme rollout follows a stepped wedge cluster design in which cohorts of sites move progressively from baseline to post-implementation states in random order.

4. Running the training programmes is subject to willingness of hospitals to participate, and their own constraints around dates and numbers of courses. This could compromise the purity of the stepped wedge design.

5. Possible confounding by another factor operating progressively over time is a limitation of our design.
Keywords
Surgery; patient safety; simulation; multidisciplinary; teamwork; protocol.
Background

Unintended harm to patients due to medical treatment is a major contributor to the global burden of disease.\(^1\) In a systematic review of studies assessing inpatient outcomes\(^2\) surgical procedures were associated with 39.6% of all adverse events and were commonly associated with unintended injury during hospitalisation. Communication failures contribute to many medical mishaps\(^3\) and sentinel events. In one study communication failures affected about 30% of team interactions in the operating theatre\(^4\), and in another they contributed to 43% of surgical errors.\(^5\) Even when operating theatre staff work hard to maintain good relationships and minimise tensions,\(^6\) disciplinary silos\(^7\) professional rivalries\(^8\) and hierarchy\(^3\) create barriers to effective communication.

The Agency for Healthcare Research and Quality recommends team training as a patient safety strategy.\(^9\) Team training has been shown to improve communication.\(^10\)\(^11\) There is some evidence that it can improve team processes, clinical processes, and potentially, patient outcomes.\(^12\)\(^13\) Team training has been shown to improve safety culture and encourage attitudes and behaviours commonly found in high reliability organisations.\(^14\) Simulation is frequently used in team training initiatives.\(^15\)\(^16\) This study protocol focuses on the evaluation of a national simulation-based team training initiative.

Healthcare for New Zealand’s population of 4.8 million people is provided through 20 District Health Boards (DHBs) of varying size, with the smallest servicing a population of around 32,000, and the largest servicing a population to over 600,000. Each DHB includes one or more publicly funded hospital. New Zealand has a national no-fault insurer, the Accident Compensation Corporation (ACC), which compensates accident victims who sustain injuries, including
injuries following treatment (known as “treatment injuries”). The number and costs of treatment injuries has increased over the last 5 years. In 2015/16 ACC accepted 8,881 medical and surgical treatment injury claims, with incurred costs of NZ$418 million. In an effort to reduce the human and fiscal toll of these events ACC is investing NZ$45 million over a five-year period into initiatives to reduce treatment injuries, targeting surgery, surgical site infections, pressure injuries, and maternity care.\textsuperscript{17} Ten million dollars of that investment is funding a multidisciplinary, simulation-based team training programme, NetworkZ.

The NetworkZ programme is run in situ in operating theatres with full surgical teams who normally work together, to be implemented in all public hospitals in New Zealand. The aim is to establish regular team simulations in each hospital operating department, supplemented by additional 30-60 minute workshops on speaking up, actively listening, structured recap and handover, and closed loop communication.

It is supported by the NetworkZ Instructor course, which trains DHB staff to deliver the programme in their DHB. A full description of the programme can be found at www.networkz.ac.nz and in Supplementary Material 1.

In a pilot study, 20 surgical teams from two large Auckland hospitals participated in NetworkZ at the University of Auckland (UOA) Simulation Centre for Patient Safety with positive participant evaluations and improved scores for observed teamwork.\textsuperscript{18-20} The national roll-out now offers an opportunity to test the impact of team training on surgical outcomes at a national level.

We propose that, for a team-training programme to have a widespread and lasting impact on teamwork and communication, it must meet a number of conditions. It should involve teams that normally work together, and take place
in the workplace, and in their own environment. It should be developed and delivered by a multidisciplinary team. It should have a sound theoretical framework for teamwork, educational approach and implementation. It should be locally ‘owned’ and led (as opposed to being externally imposed) following the initial implementation phase and the training should be provided in a ‘sufficient dose’ to involve the majority of staff in the training.

The educational framework for NetworkZ draws on the work of Kolb and Boud on experiential learning and reflective practice, and embraces interprofessional learning, gaining insights into the beliefs and roles of others, challenging assumptions, and strengthening social bonds between group members. It draws upon an evidence-based model of the features of effective teamwork conceptualised by Salas and colleagues. The key features of this model are leadership, adaptability, mutual performance monitoring, back-up behaviour and team orientation. The underpinning elements are a shared mental model, clear concise communication and mutual trust and respect.

Our implementation strategy builds on the work of Bate, and Dixon-Woods. Factors believed to foster successful implementation of initiatives such as ours include organisational support and a shared commitment to the programme, leadership engagement, staff empowerment and networking, engaging clinical champions, together with building intrinsic staff motivation. Hence implementation of the NetworkZ programme will provide extensive initial support to local project and instructor teams, senior management engagement and resourcing and follow a train-the-trainers model for local embedding and long-term sustainability. Instructors attend a two-day instructor workshop, complete on-line learning package are provided with on-site feedback and assessment as they take over responsibilities for running the course. Initial
DHB courses are led by NetworkZ faculty, mentoring local instructors to the point where they can run the courses independently. Ongoing monitoring of the quality of the simulation training is provided through centralised review of participant evaluations and end of course reports, instructor accreditation visits by NetworkZ faculty and regular advanced instructor courses. The implementation strategy is described in more detail in Supplementary Material 1.

The aim of NetworkZ is to improve outcomes for surgical patients by improving teamwork and communication in operating theatre teams through embedding regular simulation-based multidisciplinary team training in New Zealand hospitals.

**Methods**

In this study we will address the following hypotheses and research questions.

*Primary Hypothesis*

Our primary hypothesis is that surgical patient outcomes will be improved following the implementation of NetworkZ as manifested in days alive and out of hospital over 90 days (DAOH$_{90}$).

*Secondary hypotheses*

Our two secondary hypotheses are: (1) teamwork and communication processes will be improved and (2) the number and cost of ACC treatment injury claims will decline following the introduction of our training programme.

*Qualitative research questions*

We aim to: explore the factors that facilitate or impede implementation of NetworkZ; understand requirements for long-term sustainability; and identify
the types of changes occurring in the workplace following the implementation of NetworkZ.

**Trial design**

This is a mixed methods study, utilising quantitative and qualitative data in a stepped wedge, cluster randomised quality improvement design (see Figure 1). There are four cohorts of five DHBs each. Randomisation process: The 20 DHBs were divided into five groups of similar population size, calculated from publicly available Ministry of Health data on population sized served by each DHB. The first cohort comprised one DHB purposively selected from each of these five groups on the basis of capacity to start implementation. Following this initial selection, a random DHB from each size group was then selected for Cohort 2 and then for Cohort 3. The remaining DHBs comprised Cohort 4. In other words, one DHB from each size group was randomised to start the programme at the beginning of intervention period 2, period 3, and period 4 (Cohorts 2, 3 and 4).

[Figure 1 about here]

Comparison of outcomes will be undertaken between the pre-intervention period (control) starting one year before the first NetworkZ course in Cohort 1 DHBs, and the post-intervention period ending one year after the end of the transition period in Cohort 4. The transition period runs from the start of the DHB training for a Cohort, and lasts for 15 months, during which at least one third of staff in that Cohort should have attended a course. We believe that the effects from the intervention will not clearly manifest until at least 15 months, by which time a significant proportion of the staff will be trained and experienced with the intervention. No quantitative data will be collected during the transition period. We have chosen the stepped wedge cluster design
because it lends itself to a staged quality improvement project in which individual participants cannot be randomised to intervention or control.27 (see Figure 1)

**Study population**

There are two distinct populations included in the study protocol: the population of surgical patients and the population of surgical staff.

**Patient population.**

We will include patients undergoing surgery in public hospitals in New Zealand between February 1st 2016 and April 30th 2022 for patient outcome measures.

We will obtain outcome data for our primary hypothesis from the National Minimum Dataset (NMDS), a reliable administrative dataset collected by the New Zealand Ministry of Health. This data set provides a confidential and comprehensive record of all public hospital admissions and discharges in New Zealand, including demographics, ICD diagnoses, procedures, length of stay, and mortality associated with each admission. In 2017 the NMDS included 330,353 cases of publicly funded surgery.28 The funding for NetworkZ allowed us to provide the team training for five major surgical specialities: general, orthopaedics, urology, otorhinolaryngology and plastics.

For inclusion and exclusion criteria see Table 1.

<table>
<thead>
<tr>
<th>Study inclusion criteria</th>
<th>Study exclusion criteria</th>
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<tr>
<td>Surgical patient admissions</td>
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Patient admissions that meet all of the following criteria:
- receive surgery in the five targeted surgical specialities
- receive surgical intervention involving a full surgical team
- requiring an overnight stay
- receive regional or general anaesthesia
- admitted for surgery to a publicly funded hospital that has been, or will be, involved in the NetworkZ programme.

All subsequent readmissions to any hospital facility within the following 90 days will also be included.

Patient admissions that meet any of the following criteria:
- admitted and discharged on the day of surgery
- admitted to private hospitals
- receiving endoscopy using operator supervised sedation
- procedures requiring local infiltration only
- patients admitted to stand-alone paediatric hospitals.

Hospital staff

Public hospital staff working in one of the following roles:
- surgical specialists in the included five speciality groups
- anaesthetic specialists
- nursing staff working in operating theatres
- anaesthetic assistants (referred to as Anaesthetic Technicians in New Zealand)

Hospital staff working as:
- trainees in surgery or anaesthesia
- solely specialised paediatric hospital employees
- house surgeons (junior doctors not in specialist training programmes)
- health care assistants
- solely private hospital employees.

Patient sample size and power analysis

The sample will be all patients undergoing surgery in public hospitals during the study period who stay at least one night in hospital and are undergoing procedures in the included speciality groups. This number has been estimated from NMDS historical data to be in the order of 550,000 cases over the six-year study period.

Our sample size is primarily pragmatic. Both our design (i.e. stepped-wedge) and primary outcome variable (i.e. DAOH) present significant obstacles to
conventional sample size calculations. Nonetheless, we have undertaken an empirical power analysis on simulated data. We generated smooth sampling distributions from historical data for each DHB. This historic data feature the cohort structure of DHBs, and the within-DHB clustering of patients likely to be present in our future study data. We also generated versions of each distribution with a difference imposed at given quantiles by either flattening or accentuating the peaks in the data (i.e. a larger late peak means more patients with better DAOH). Using the recruitment parameters of our study, we generated 1,000 synthetic datasets with a simulated intervention effect. We compared the control and intervention groups using the Wilcoxon-Mann-Whitney U test, and assessed the significance of the calculated statistic by randomly permuting sites between cohorts 1,000 times. Our simulations indicate a greater than 95% power at \( \alpha=0.05 \) to detect an intervention effect of one or more DAOH at the median, and two or more DAOH at the 0.25 quantile. We may apply quantile regression risk-adjustment to statistically evaluate differences of less than one DAOH (i.e. the minimum resolution of unadjusted DAOH data).

**Operating theatre staff population**

NetworkZ aims to train the majority of eligible staff working in the operating theatres of New Zealand public hospitals. Because there are four Cohorts with a staged annual roll out from 2017 to 2020 inclusive, the expected proportion of eligible operating theatre staff attending training over the study period are: 100% of Cohort 1; 75% of Cohort 2; 50% of Cohort 3; 25% of Cohort 4, and this is the basis of our sample size estimate. For surveys the unit of analysis will be the individual, while for observations, the unit of analysis will be the theatre team. See Table 1 for inclusion and exclusion criteria.
Total surgical staff population size

From specialist registration boards and hospital staffing lists we estimate the following: specialist surgeons ~730; specialist anaesthetists ~750; operating theatre nurses ~1800; anaesthetic technicians ~480. (Total = ~ 3,800 staff)

Operating theatre staff sample size estimate

For surveys, we will include all staff meeting the inclusion criteria. We will rate between 5 and 10 cases in each DHB in the three-month period prior to the introduction of NetworkZ in that DHB and immediately following the transition period in that DHB. Over the course of the study this will generate between 100 and 200 in the pre-NetworkZ period and a similar number in the post-NetworkZ period. Previous work indicates that fewer than 20 cases before and 20 after an intervention can detect a difference of one point on the seven-point WHOBARS scale in 80% of cases. We are undertaking more observations to obtain a representative sample across DHBs.

Outcome measures

Primary outcome measure (addressing primary hypothesis)

The primary outcome measure for the study is Days Alive and out of Hospital after 90 days (DAOH$_{90}$), recently validated for the surgical context. DAOH provides a holistic approach to measuring patient harm that incorporates mortality and length of time out of hospital for a defined number of days (in this case 90 days) following an index event (in this case, a surgical procedure). Days in hospital include those until discharge following surgery, and those during any readmissions to public hospitals within the specified 90-day postoperative period. DAOH$_{90}$ scores will be affected by mortality and any complications that either prolong hospitalisation or result in readmission.
DAOH₉₀ score will be zero for patients who die without ever leaving hospital, but any day alive and out of hospital during the 90-day period will be counted.

Index procedures for DAOH₉₀ will be limited to patients who stay in hospital for at least one night. The rationale for this is to restrict the patient population to those at higher risk of adverse events, and to increase the likelihood that when a patient is admitted for a diagnostic procedure prior to definitive surgery, the 90-day period begins with this definitive surgery. A surgical admission within 90 days will be subtracted from the 90 days when calculating DAOH₉₀.

Additionally, we will explore the influence of the proportion of staff in each DHB who have attended a NetworkZ course. In a secondary analysis we will also calculate Days out of Hospital and Mortality separately to tease out the individual effects of these on the primary outcome. The analysis will follow the procedure for the analysis of the primary outcome measure.

**Statistical analysis**

Using the Stepped Wedge cluster design we will analyse the differences between pre- and post-NetworkZ cohorts on each of the patient outcome measures. Data will be classified into pre-NetworkZ (control), transition, and post-intervention intervention categories (see Figure 1).

Due to the highly skewed and bimodal nature of the DAOH₉₀ scores (see Figure 2), we will use the non-parametric Wilcoxon-Mann-Whitney rank sum test as our primary test to derive a statistic for the overall difference between distributions before and after implementation of NetworkZ. To assess the significance of the difference, we will compare the statistic to the values derived from 10,000 random permutations of cluster (i.e. DHB) to sequences (i.e. cohorts). Our permutation test will differ from that demonstrated by Thompson, et al. ³² in
that we will not use within-period comparisons. The distribution of the test statistic generated by this procedure may not be centered at zero, particularly if there is confounding of the control versus intervention comparison with an overall temporal effect. For this reason, the observed test statistic will be compared with the centre of the generated distribution. We have implemented this in R. The permutation test does not vary the timing of an individual patient’s admission, rather an individual patient will be permuted with all other patients in their cohort, as they will be assigned to the intervention based on the interplay between their actual time and the cohort sequence to which they are permuted. Thus, the null distribution of the Mann Whitney U test will account for any overall temporal effects within the dataset.

We will then perform quantile regression at the 0.1, 0.25, 0.75, 0.9 quantile to characterize any difference between the two distributions. This quantile regression will include time (month and year of procedure) in order to adjust for time effects, cohort, DHB (within cohort) and intervention as factors in the model. To assess the impact of the purposive sampling of Cohort 1 DHBs, we will conduct a sensitivity analysis by re-running the above analysis using Cohort 2, 3, and 4 data.

[Figure 2 about here]

Secondary outcome measures (addressing secondary hypotheses)

Teamwork Perceptions Survey

The Teamwork Perceptions Survey was designed to align with the intended learning outcomes of NetworkZ (Supplementary material 2). Items were drawn from behaviours of effective teams described by Salas and refined through review and consensus with an expert group. The survey will be administered to
all operating theatre staff who are regularly working in operating theatres in the specialities targeted by the course.

This survey will be administered in the 3-month period prior to a DHB commencing training and repeated at the end of the transition period (at 15 months). Staff in DHBs around the country will be assigned unique confidential identifiers. These identifiers will be used in the surveys to enable matching of participants' pre- and post- intervention survey responses and determine if they have participated in NetworkZ.

Analysis

Pre- and post-Teamwork Perceptions Survey total scores and subscale scores will be assessed using a Generalized Linear Mixed Model (GLMM). The analysis will include terms for cohort, DHB (random effect nested within cohort), intervention, month and year, with the primary comparison using the cohort as the replicate of the intervention effects. Small sample correlations will be considered. Additionally, we will explore the influence of the proportion of staff in each DHB who have been trained.

Surgical Safety Culture Survey (SSCS)

The SSCS measures attitudes and behaviours relevant to surgical safety and survey scores have been shown to predict 30-day risk of post-operative death. The Health Quality and Safety Commission (HQSC) has made minor changes to the survey terminology for the New Zealand context. HQSC administers this national survey to all operating theatre staff on a bi-annual basis. The survey is anonymous but includes demographics such as DHB and professional role. HQSC administered the survey in February 2017 with subsequent administrations planned for February 2019 and February 2021.
Analysis

Pre- and post-SCSS total scores and subscale scores will be assessed using a GLMM. The analysis will include terms for cohort, DHB (random effect nested within cohort), intervention, month and year, with the primary comparison using the cohort as the replicate of the intervention effects. Small sample correlations will be considered.

Observations of WHO Surgical Safety Checklist administration

We will utilise the World Health Organisation Behaviourally Anchored Rating Scale (WHOBARS) observation tool previously developed and validated by members of our research group (see Supplementary material 3). WHOBARS measures the quality of administration of the Surgical Safety Checklist (SSC). The SSC is used almost universally in New Zealand and provides a standardised opportunity to share important information with other members of the surgical team. Changes in teamwork and communication should be reflected in this measure. Case selection for the WHOBARS observations will be a convenience sample of available cases over a 3-day rating period in each DHB and will include any surgical case that falls within the eligibility criteria for NetworkZ. We will record unique staff identifiers for each team observed to enable post-NetworkZ influence of the number and role of staff in a team who have participated in a NetworkZ course. In order to generate reliable scores we will train raters using a series of videos and actual theatre cases.

Analysis

The analysis will compare mean and subscale WHOBARS scores for surgical teams pre- and post- the NetworkZ intervention using a GLMM. The analysis will include terms for cohort, DHB (random effect nested within cohort), intervention, month and year, with the primary comparison using the cohort as...
the replicate of the intervention effects. Small sample correlations will be considered. We will also undertake an exploratory analysis to investigate if the proportion of staff trained moderates the difference between pre- and post-training.

**Number and costs of ACC treatment injury claims**

To provide an indication of the fiscal outcomes of the intervention, surgical treatment injury claims submitted to ACC will be analysed using claims that are relevant to the surgical specialties targeted by NetworkZ. We will exclude claims that relate to specialties not included in NetworkZ. We will analyse ACC data using the same patient population groups over the same time-periods as established for the stepped wedge design for the primary analysis. The analysis will compare claim data pre- and post- the NetworkZ implementation using a GLMM. The analysis will include terms for cohort, DHB *(random effect nested within cohort)*, *intervention, month and year*, with the primary comparison using the cohort as the replicate of the NetworkZ effects. Small sample correlations will be considered. We will conduct separate analyses for the number and cost of claims.

**Post-operative complications captured in the NMDS**

To provide secondary data around patient safety, we intend to examine post-operative complications available in the NMDS. The NMDS captures information about new diagnoses that emerged as a result of surgical complications and instances of medical misadventures during surgery that have been captured in medical notes. This data will be analysed using the same patient population groups over the same time periods as the primary analysis.

**Sick leave records**
Improved teamwork has the potential to reduce staff retention and the use of sick-leave. We will assess monthly OR staff time off from illness by DHB to assess if there are reductions in sick leave following introduction to the programme.

**Qualitative measures (addressing qualitative research questions)**

We will undertake interviews with each Cohort to address the three qualitative research questions. We will conduct semi-structured interviews with DHB staff involved in NetworkZ on the project team or as instructors. We will identify potential participants through the NetworkZ database and sampling will be purposive to include a range of views from large and small DHBs, from different professional groups, and those with different roles. Sampling will continue to the point of data sufficiency, when no new themes are emerging and existing themes are sufficiently described. We anticipate a sample size of 20-30 interviews per Cohort. Timing of interviews will be during the transition period, during the period of implementation of NetworkZ. Interviews will be transcribed and coded using NVivo prior to framework analysis or general thematic analysis.

**Patient and public involvement**

There was no patient or public involvement in the development of this study protocol.

**Ethics and dissemination**
This study has been approved by the New Zealand Health and Disability Ethic Committee (HDEC) (#16/NTB/143). The committee waived the requirement for individual patient consent.

The protocol was registered with the Australian and New Zealand Clinical Trials Registry (ANZCTR) on 5th January 2017 and last updated on 7 August 2018. The protocol title is “Evaluation of NetworkZ: Can multidisciplinary team-training improve the safety of surgery in New Zealand?” The Trial ID is ACTRN12617000017325 and the Universal Trial Number is U1111-1189-3992.

Discussion
NetworkZ is a nationwide response to the global need to improve the safety of surgical care. To our knowledge this will be the first occasion when a surgical team training initiative has been implemented on a national scale. Access to routinely collected health data at a national scale is key to the feasibility of our evaluation.

The unique features of NetworkZ team training include: interactive surgical models integrated with computerised full-body computerised manikins that allow all members of the surgical team to participate; in situ training using real teams in real operating theatres; providing simulation resources and instructor training to build local capacity to independently run the course.

Strengths of the study
This is a national study, involving multiple sites and large numbers. It is adequately powered to show a difference in DAOH if one exists. Access to high-quality data routinely-collected nationally on hospital events is a major strength, without which the study would not be feasible.
Our primary outcome measure, DAOH, is a relatively new measure for surgical patient outcomes, recently validated for the surgical context.\textsuperscript{30} DAOH\textsubscript{90}, provides a holistic evaluation of surgical outcomes that is sensitive to any cause of death, prolonged hospital stay or readmission. This measure can be reliably and cost-effectively derived from the data in the NMDS and is objective. Stepped wedge cluster design is very suitable for quality improvement initiatives in which it is impossible (or at least highly impracticable) to randomise individual cases or participants.\textsuperscript{27,37} It is uniquely suited to initiatives that are rolled out over time.

Another strength of our study is the mixed methods approach. The secondary outcome measures and qualitative data can provide supporting evidence of change attributed to NetworkZ and provide complementary insights into whether the programme is working as intended and why the programme is or is not working.

**Weaknesses of the study**

Team training interventions may take time to have an effect and we may thus fail to detect an effect due to sampling too early. Due to the limited timeframe for implementation of training in the initial Cohort as dictated by our funding contract, Cohort 1 DHBs were not selected randomly, but were purposively selected as we had an existing relationship with those DHBs. There are anticipated limitations of exploring the effect of quality improvement initiatives in the real world, including implications for standardisation, randomisation and control groups. For example implementation of training depends on the willingness of DHBs to support NetworkZ, local staff to undertake the Instructor Training, and DHB staff to attend the courses.
Despite numerous measures to achieve consistent, high quality training, there are challenges in achieving standardisation of NetworkZ delivery in individual DHBs where the local staff take on the responsibility for implementing the program in their own environments.

Due to the potential for other factors progressively influencing patient outcomes over time, we will not be able to prove that the changes can be attributed to NetworkZ. This will be mitigated to some extent through the stepped wedge design and triangulation with measures of teamwork through surveys and observations.

**Conclusion**

With the financial support of our publicly funded Accident Compensation Corporation, the unique opportunity exists to implement and evaluate a nationwide team-training initiative for full operating theatre teams in all public hospitals in New Zealand. By using a pre-existing large administrative data set, we have the potential to demonstrate a difference to surgical patient outcomes from this quality improvement team-training initiative.

**Acknowledgements**

The authors would like to express special gratitude to Kaylene Henderson, Jane Torrie, Richard Hamblin and Ian Civil for their tireless efforts in the development and delivery of the NetworkZ programme, and the ongoing support of its evaluation.

**Data statement**
At the conclusion of the study de-identified Teamwork Perceptions Survey data will be available on reasonable request from cmhseadmin@auckland.ac.nz, for a period of five years for academic purposes. Other data that will be utilised in this study either cannot be adequately de-identified or was obtained from third-party databases that the authors do not have authority to grant access to.

Conflict of interest statement
Dr. Merry is Chair of the Health Quality and Safety Commission NZ and a director of SaferSleep LLC. Both Dr Merry and Dr Webster hold shares in SaferSleep LLC.

Funding
This delivery and evaluation of NetworkZ is funded by the Accident Compensation Corporation of New Zealand, and supported by grants from the Australian and New Zealand College of Anaesthetists (2017 Douglas Joseph Professorship Grant, Project Number DJ17/001), and the Lottery Health Research Fund (Project Number: R-LHR-2017-49141).

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References


Figure 1. The stepped-wedge cluster cohort design.

Figure 2. Probability density graph for the distribution of DAOH based on historical data from 2011-07-01 to 2016-06-30 (blue dotted) and the same with a simulated difference of one day imposed at the median (red solid). Note square root transform on y-axis.
Cohort 1
Begins Feb 2017

Cohort 2
Begins Feb 2018

Cohort 3
Begins Feb 2019

Cohort 4
Begins Feb 2020

--- Measurement begins 1 February 2016 ---

Measurement ends 30 April 2022 ---

Key:
- Pre-NetworkZ (Control) period
- Transition period (15 months)
- Post-NetworkZ period
Supplementary material 1

The NetworkZ programme and implementation process

The NetworkZ course

The NetworkZ course full-day course comprising simulated scenarios, debriefs, presentations and group discussion the full-day NetworkZ course can be delivered as two half-day courses in order to minimise operational disruption and thus maximise acceptability. The long-term aim is for all operating theatre staff in New Zealand public hospitals to complete a full day of training at least every three years. The course is designed for the five surgical specialties with the largest number of surgeons: general, orthopaedics, otorhinolaryngology, urology and plastics. Obstetrics and gynaecology for which a simulation training programme (non-OR) already existed was not included.

Scenarios:

When implementation has been completed 25 simulated scenarios will have been developed from actual cases of co-morbid patients presenting for surgery with a range of conditions such as trauma, sepsis, abdominal and post-operative airway emergencies. Simulated scenarios last between 25 and 45 minutes and the scenarios are designed to be challenging and complex with multiple decision points for the entire team. Scenarios begin prior to induction of anaesthesia and include detailed case notes, supporting documentation, imaging and investigations. They take place in each team’s actual operating theatre using available anaesthetic and surgical equipment, drugs and fluids and other consumable items, with formalised strategies to manage known risks of in-situ simulation.\(^{(37)}\)

The simulations use the Laerdal 3G SimMan manikins\(^{(38)}\) with moulage and custom built face masks and body suits, combined with surgical models to maximise fidelity, to convey different simulated patients and to provide appropriate surgical, anaesthetic and nursing tasks. Examples of the surgical models include a ruptured appendix, a traumatic leg amputation and, and a neck haematoma compromising the airway. The models permit surgical interventions including incision, haemorrhage
control, suturing, resection, and anastomosis. The manikin is pre-programmed to convey patient status at various phases of the scenario with supervisory control to respond to unexpected participant actions. A full surgical team participates in each scenario including at least one specialist surgeon and one specialist anaesthetist, three theatre nurses and an anaesthetic assistant. Surgical and anaesthesia trainees often participate as do health care assistants and post-anaesthetic care unit nurses. NetworkZ faculty observe from behind a partition, screen or via video-link (depending on local facilities). Faculty control the manikin and surgical models in response to participant actions and answer participant phone calls for assistance or advice following scripts which replicate local processes. The scenarios are not recorded and there are no participant observers. Participants are supported by a ‘confederate’ nurse or anaesthetic assistant who is in communication with the instructional team. The confederate assists with clinical tasks in the simulated environment such as taking blood samples or by discreet communication of physical signs unable to be replicated by the manikin or models (e.g. deviated trachea).

Debriefing: The scenario is followed by a facilitated debrief with 2 trained NetworkZ instructors using three distinct phases: Phase 1 participant reactions; Phase 2 description, analysis, application; Phase 3 personal transfer to practice. Questioning approaches emphasise open questions and advocacy enquiry. Debriefers refer to specific communication tools and teamwork behaviours from the Salas model with the aid of wall-mounted posters. Systems issues identified in the debrief are recorded and reported back to the local quality improvement leader for follow up.

Interactive Presentations: Purpose-designed trigger videos and animations are used to emphasise communication strategies and specific tools for briefing the team. The strategies and tools include ISBAR, closed loop communication, speaking up, and structured recapping. Participants are encouraged to explore their
different professional roles, perspectives and assumptions to develop strategies to work together more effectively.

**NetworkZ instructor training**

The NetworkZ course quality is assured by the requirement for instructors to demonstrate competency in ten domains of practice, using Entrustable Professional Activities (EPAs)\(^{(41)}\) as an organising framework for the curriculum. These domains are: fundamentals of effective teamwork; creating a safe learning environment; conducting a scenario; identifying learning points while observing a scenario; conducting a debrief; evaluating learning; managing risk with in situ simulation; preparing the clinical environment for simulation, operating the simulation equipment; and maintaining simulation resources.

The EPAs are mastered using a blended approach to course delivery that includes face-to-face workshops, online learning and apprentice-ship style learning with observation and feedback from senior faculty. Instructor assessment includes online submissions and assessment of performance.

**Implementation strategy**

Our approach to implementation is multifaceted, incorporating multiple stakeholders; national bodies included central committees of the 20 New Zealand District Health Board (DHB) executives, the Royal Australasian College of Surgeons, the Australian and New Zealand College of Anaesthetists; New Zealand Nursing Council; and Institute of Anaesthetic Technicians. Approximately 12 months prior to the introduction of NetworkZ, the NetworkZ project team meet the DHB senior executive team, and negotiate a formal letter of agreement with the Chief Executive. This outlines the gift of a 3G Laerdal simulator and some surgical models to the DHB, provision of training and support by the NetworkZ project team and the expectations of DHB support for release of staff to attend training with provision of the training venue. In each DHB local project teams are established with connections to senior executive and quality assurance leads. A local group of instructors are nominated and undertake training. NetworkZ training in the DHB is initially supported by UOA faculty but gradually devolved...
to local DHB instructors as they complete NetworkZ instructor training. After 12 to 15 months, DHBs assume full responsibility for running the NetworkZ course in their DHB. UOA maintains a role in quality improvement, quality monitoring, instructor training and course development.
Teamwork Perceptions Survey

Please rate the following components of teamwork in the operating theatre teams where you regularly work. We acknowledge that your experiences will vary between different theatre teams. Please try to give an average rating for your experiences of teamwork across the theatres where you regularly work, rather than rating one specific theatre team.

Please note this is about the whole theatre team, including surgeons, nurses, techs and anaesthetists.

SA = Strongly Agree; A=Agree; N=Neutral; D=Disagree; SD=Strongly Disagree

<table>
<thead>
<tr>
<th>In general, in theatres where I regularly work, senior staff (e.g. consultant surgeon and anaesthetist, senior nurse, charge tech):</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>1. Provide clear directions to the team</td>
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<td>2. Use an appropriate balance of assertiveness and support</td>
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<td>3. Motivate team members to do their best</td>
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<td>4. Establish a positive atmosphere in theatre</td>
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<td>5. Facilitate team problem solving during the case</td>
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<td>6. Role model acceptable interaction with colleagues</td>
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<td>7. Engage in pre case briefings of the whole team</td>
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<td>8. Co-ordinate tasks and individual team member contributions to patient care</td>
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<th>Team members:</th>
<th>SA</th>
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<td>9. Provide support to each other</td>
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<td>10. Shift work responsibilities to underutilised team members at times of high workload</td>
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<td>11. Keep an eye on other team members’ performance</td>
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<td>12. Speak up about potential mistakes or lapses in other team members’ plans or actions</td>
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<td>13. Provide constructive feedback regarding team member actions to facilitate self-correction</td>
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<td>14. Are willing to acknowledge mistakes and accept feedback</td>
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<td>15. Value the input of all team members to patient care</td>
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<td>16. Take into account alternative solutions offered by other team members</td>
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</table>
17. Share information about the case planning, progress and concerns with other team members

18. Involve the whole team in planning patient care

19. Have a good understanding of the roles and abilities of their teammates

20. Anticipate and predict each other’s needs

21. Have a lot of respect for each other

22. Enjoy working together

23. Exchange information clearly and concisely

24. Use names frequently when communicating information or allocating tasks

Global rating

| SA | A | N | D | SD |

25. Overall, the theatre teams I work in demonstrate effective teamwork and communication behaviours

Comments

Which hospital are you completing this survey for?

What is your role in the operating theatre? (Please tick one)

- Consultant surgeon
- Consultant anaesthetist
- Anaesthetic technician
- Other (please specify)
- Surgical registrar/fellow
- Anaesthetic registrar/fellow
- Theatre nurse

Male [ ] Female [ ]

Which of the following best describes your ethnicity? (Please tick one)

- New Zealand European
- Pacific Peoples
- Asian Indian
- Other (please specify)
- Māori
- Asian
- Other European

Thank you for taking the time to complete this survey
WHOBARS: SIGN IN [A]

Sign In not done at all ☐

1. Setting the Stage

The Checklist is initiated appropriately.

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**Poor**

- Establishing Readiness
  - Checklist reader starts reading out Checklist items without establishing readiness of participants.
  - Sign In is begun while one or more of the team are doing other things (e.g., the anaesthetist is inserting a line).
  - Sign In starts by the Checklist initiator raising his or her voice rather than establishing readiness.
  - Sign In is begun after the induction of anaesthesia.

**Excellent**

- Establishing Readiness
  - The Checklist initiator says something like “Is everyone able to take a couple of minutes for the Checklist?” or (to an individual) “Are you free to do the Sign In now or should we wait a minute or two?”
  - The anaesthetist says something like “I just need to finish this—can we wait a couple of minutes please?” The Checklist reader then waits until the anaesthetist is ready.
  - Sign In is begun when patient first enters room before any drugs are administered.

Comments:

2. Team Engagement

All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

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**Poor**

- Supportive
  - Anaesthetist says something unsupportive like “How long is this going to take? I need to get on with some real work.”

- Engagement
  - A key team member is absent from the room during Sign In (e.g., the anaesthetist).
  - Anaesthetist and/or nurse continue doing their work, attempting to multi-task.
  - Any person in the room conducting conversations, speaking on the phone, hooking up equipment, and so on instead of concentrating on the Sign In.

**Excellent**

- Supportive
  - Anaesthetist says something supportive like “Thank you, Jane [to Checklist reader]. Could everyone pay attention please? This is important.”

- Engagement
  - All team members stop other activities and concentrate on the Checklist.
  - Surgeon, if present, participates at least by listening and by supportive body language.
  - Patient, if not too sedated, has process explained and is invited to confirm key points.

Comments:

3. Communication: Activation

Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

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</table>

**Poor**

- Communication
  - No names are used.
  - Speaking softly indicating a private rather than shared conversation.

- Inclusiveness
  - Senior team member makes a derogatory remark when someone asks a safety-related question or points out an important fact.
  - Body language is exclusory (e.g., no eye contact) or hostile (e.g., angry expression).

**Excellent**

- Communication
  - Senior team member says something to the effect that she hopes that people will speak up if they see something they don’t understand or think there is a possible problem.

- Inclusiveness
  - Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.

Comments:
4. Communication: Problem Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

1 2 3 4 5 6 7

Poor

PATIENT INFORMATION
- The nurse reminds the team that the patient is allergic to several drugs after the induction drugs have been administered.

EXPRESSED CONCERN
- Uncertainty is expressed about the potential for blood loss, but no one speaks with the surgeon to check.
- Anaesthetist pays no attention and fails to respond to the question even by saying something like “I have no concerns.”
- Surgeon says something like “There is no time for this—people should know what to expect.”
- The anaesthetist says that there is a potential difficulty with intubation but is not provided adequate assistance or support or time to deal with this problem.

Comments:

Excellent

PATIENT INFORMATION
- Team member points out a potentially important clinical fact about the patient (e.g., “this patient has diabetes”)
- Surgeon says something like “Jim [to anaesthetist] you do know this patient’s uncle had problems with anaesthesia, don’t you?”
- Surgeon asks something like “does anyone know anything else about this patient that might worry us?”

EXPRESSED CONCERN
- In response to airway question, anaesthetist says that there may be difficulty, and makes sure that the difficult airway trolley is in the room and that there is adequate assistance on hand.
- In response to airway question, anaesthetist says something like “Airway is fine.”
- Anaesthetist says something like “I have no concerns about this patient.”
- Nurse says something like “Jim [to anaesthetist], are you worried about that IV? I wonder if it is big enough if we get into trouble with blood loss.”

Comments:

5. Communication: Process Completion

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

1 2 3 4 5 6 7

Poor

PROCESSES & PROCEDURES
- Anaesthetist fails to acknowledge one or more of the questions about airway, the readiness of anaesthetic machine, blood loss, etc.
- All of the team state that side is correct without anyone checking surgical site marking.

Comments:

Excellent

PROCESSES & PROCEDURES
- Site confirmed as marked and visible by nurse, anaesthetist and surgeon.
- Checklist reader checks patient name and number with team members referring to patient’s wristband.
- Anaesthetist crosschecks site verification with patient (if not too sedated), saying something like “Mrs Smith, can you just confirm for me, one more time, which knee we are operating on?”

Comments:
WHOBARS: TIME OUT [S]

1. Setting the Stage

The Checklist is initiated appropriately.

**Poor**

- ESTABLISHING READINESS
  - The Checklist reader starts reading out Checklist items without establishing readiness of participants.
  - Time Out is begun while one or more of the team are doing other things (e.g., assembling the sterile field, assessing anaesthesia).
  - Time Out is initiated after the first surgical incision.

- MANNER
  - Checklist is read quickly and the answers are assumed without pausing to check that the surgeon and anaesthetist agree with the answers.

**Excellent**

- ESTABLISHING READINESS
  - The Checklist initiator says something like “Is everyone able to take a couple of minutes for the Checklist?” or (to an individual) “Are you free to do the Time Out now or should we wait a minute or two?”
  - The Checklist initiator says something like “Can we do the Time Out now, please? Is everyone ready to take part?”
  - Time Out is called at the end of prepping and draping, prior to surgical incision.

- MANNER
  - The Checklist initiator thanks people for their input or acknowledges input in a positive way (i.e., eye contact, a friendly nod).
  - The Checklist reader uses an assertive tone of voice conveying a commitment to the Checklist process.

**Comments:**

2. Team Engagement

All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.

**Poor**

- SUPPORTIVE
  - Someone says something like “This is a waste of time.”

- ENGAGEMENT
  - Key members talk on the phone or to each other during Time Out.
  - The surgeon says something like “Let’s get on with the checklist,” but then walks out of the room while it is being administered.
  - Key members continue with preoperative tasks during the Checklist, attempting to multi-task.
  - The registrar occupies self with other activities instead of paying attention.

**Excellent**

- SUPPORTIVE
  - Surgeon or anaesthetist says something like “Thank you, Jane [to checklist reader]. Could everyone pay attention please? This is important.”

- ENGAGEMENT
  - All team members stop other activities and concentrate on the Checklist.
  - Someone asks a question about something that he or she did not understand.
  - Anaesthetist refers to patient chart to verify critical patient information as it is read out.

**Comments:**

3. Communication: Activation

Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.

**Poor**

- COMMUNICATION
  - Some team members state name but not role during introductions.
  - Communication during the Checklist process is undirected, even by body language, and people speak to “thin air” rather than to each other.
  - INCLUSIVENESS
    - Senior team member makes a derogatory remark when someone asks a question they might have been expected to know the answer to.
    - Observers such as students are ignored and not introduced.
    - A negative remark is made about someone raising a patient safety concern.

**Excellent**

- COMMUNICATION
  - Every OR team member clearly states name and role during introductions.
  - The Checklist reader confirms that everyone knows each other, perhaps because introductions occurred in a previous case.
  - INCLUSIVENESS
    - Every person in the OR is acknowledged during the introductions.
    - Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.
    - Circulating nurse is given opportunity to view consent form prior to first incision and confirms it aloud to all team members.
    - Observers such as students are introduced.

**Comments:**
4. Communication: Problem
Anticipation

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

**Poor**

**Examples**
- **PATIENT INFORMATION**
  - Procedure is not delayed although an item of potentially important information is missing.
  - The surgeon indicates a potential for considerable bleeding, but the anaesthetist, who has inserted a small IV line, does not respond by supplementing this.
  - Surgeon says something like "Can we just get on with the procedure please—people should know what to expect."

**EXpressed CONCERN**
- Poor
- Excellent

**Comments:**

5. Communication: Process
Completion

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

**Poor**

**Examples**
- **PROCESSES & PROCEDURES**
  - Anaesthetist says something like "Oh thanks—just giving the antibiotic now", but surgeon says something grumpy and proceeds to make incision anyway, without waiting for this to happen (i.e., he ignores the message).
  - The Checklist reader asks "Has antibiotic been given within last 60 minutes?" There is no response, but reader carries on with Checklist regardless.
  - All of the team state that side is correct without anyone checking surgical site marking.

**Excellent**

**Examples**
- **PROCESSES & PROCEDURES**
  - Anaesthetist says something like "Sorry, I was distracted—I will just give the antibiotic now", and surgeon says something like "OK, thanks for that," waits for it to be given and allows some time for it to work before making an incision.
  - The Checklist reader prompts team members for further information, such as lack of clarity over confirmation that the patient has had thrombo-prophylaxis.
  - Surgeon asks anaesthetist, "Can you please tell me the antibiotic which was given, which one, how much, and at what time."
  - Surgeon and anaesthetist check key blood products are available.
  - Patient’s identification is re-checked and verified.

**Comments:**
### 1. Setting the Stage

**The Checklist is initiated appropriately.**

<table>
<thead>
<tr>
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<tr>
<td><strong>ESTABLISHING READINESS</strong></td>
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<tr>
<td>- Sign Out is done after surgeon has left the room or has left the table and is trying to do something else like write the operation note.</td>
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<td>- The Checklist reader starts reading out checklist items without establishing readiness of participants.</td>
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<td>- Sign Out is performed when all team members are present, but during the transfer of the patient from table to bed, i.e. with no “pause.”</td>
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<tr>
<td><strong>MANNER</strong></td>
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<td>- Checklist reader uses tone of voice that suggests apathy, disinterest or disdain for the checklist process.</td>
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<td>- The Checklist initiator says something like “Can we do the Sign Out now, please? Is everyone ready to take part?”</td>
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<td>- Sign Out is initiated as skin is being closed with all team members present and able to participate.</td>
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### 2. Team Engagement

**All team members participate in the Checklist process in an engaged and attentive manner supportive of the process.**

<table>
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<tr>
<td><strong>ENGAGEMENT</strong></td>
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<td>- Surgeon has already left theatre.</td>
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<td>- Surgeon says “You guys take care of this” and walks out.</td>
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<td>- Scrub nurse continues to tidy instruments and ignores process.</td>
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<td>- Anaesthetist and/or nurse continue doing their work, attempting to multi-task.</td>
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<tr>
<td><strong>SUPPORTIVE</strong></td>
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<td>- The surgeon says something like “I am going to let the resident close. Would it be OK to do the sign out now and then I can go and see the next patient while the rest of you finish off?”</td>
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<tr>
<td>- All team members stop other activities and concentrate on the Checklist.</td>
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<tr>
<td>- Scrub nurse stops all other activity and says something like “Are we all sure this patient’s coags are okay? He still looks pretty wet to me.”</td>
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<td>- Anyone asks a question about some aspect of the patient’s care.</td>
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### 3. Communication: Activation

**Activation of all individuals using directed communication and demonstrating inclusiveness by encouraging participation in the process.**

<table>
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<tr>
<td><strong>INCLUSIVENESS</strong></td>
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<tr>
<td>- Senior team member makes a derogatory remark when someone asks a question they might have been expected to know the answer to.</td>
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<tr>
<td>- During Sign Out, the anaesthetist indicates the need for additional time to ensure patient is safe but receives an unsupportive response.</td>
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<td>- Nurse indicates swab count is not correct and receives a critical or unsupportive response.</td>
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<tr>
<td><strong>Examples</strong></td>
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<tr>
<td>- Senior team member thanks someone for asking a safety-related question or pointing out a possibly important fact.</td>
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<tr>
<td>- Nurse indicates that swab count is not correct, and surgeon thanks him or her for helping to avoid a problem.</td>
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<td>- The swab count indicates a missing swab, and the surgeon says something like “Thanks—we had better have another look behind the heart.”</td>
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**WHOBARS: SIGN OUT**

**4. Communication: Problem Anticipation**

Critical patient information is reviewed and matters of concern are discussed and addressed appropriately.

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**Examples**

- **EXPRESSED CONCERN**
  - Team member speaks up about potential difficulty with equipment for the next procedure and receives an unsupportive or critical comment from the surgeon.
  - Information about a potential problem is ignored.
  - Anaesthetist comments to scrub nurse, after surgeon has left, something like “I was a bit worried about patient’s post op pain management because epidural wasn’t working, but I didn’t want to bother the surgeon.”

- **PATIENT INFORMATION**
  - Surgeon says to resident who will be writing orders, “Remember that this patient has an epidural, so our anticoagulation can only be unfractionated subcutaneous heparin until after the epidural is removed.”
  - Surgeon says to anaesthetist, “This patient may have significant pain problems, so a dose of ketorolac now might be helpful for early postoperative pain relief.”

- **EXPRESSED CONCERN**
  - Anaesthetist verbally discusses immediate and early postoperative measures to ensure patient safety.
  - Surgeon verbally hands over instructions relating to drain outputs and early post-operative care.
  - Specific elements of postoperative care are reviewed such as need for anticoagulants, postop antibiotics yes/no, pain management plans, need for special monitoring, etc.
  - Surgeon says something like “I am worried this patient is oozy. John [to the anaesthetist] could you ask the ward to organize a coagulation screen please?”
  - Anaesthetist says something like “Thanks. I really appreciate the opportunity to discuss this patient’s poor respiratory reserve—I think he might get into trouble overnight.”

**Comments:**

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**5. Communication: Process Completion**

Key safety processes and procedures are reviewed and verified as completed or addressed appropriately if not.

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**Examples**

- **PROCESSES & PROCEDURES**
  - Specimen is (or has been) sent off without checking label.
  - The swab count shows a missing swab, and the surgeon says something like “You guys can’t count” and proceeds to close anyway.
  - Nurse indicates that swab count is correct, but there is no response to confirm that the surgeon has heard.

- **PROCESSES & PROCEDURES**
  - Instrument and swab count completed and persistent search is carried out for a missing item until it is found.
  - Surgeon checks that the team have stored and labelled the specimens correctly.
  - Surgeon requests circulator to read the label (specimen and patient name) on the specimen to confirm that it is correct.

**Comments:**