Abstract of dissertation entitled

“The Effect on Perioperative and Postoperative Oxygen Supplementation on Surgical Site Infection Rate in Colorectal Surgery”

Submitted by

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Surgical site infection is a commonly seen post-operative complication in colorectal patients. It is a crucial problem as it is not only cause of morbidity and mortality, but it also brings substantial financial burden to the hospital and the healthcare system. To minimize the clinical consequences of surgical site infection, it is vital to develop appropriate measures timely in order to relief such phenomenon. Previous studies found that administration of 80% oxygen concentration intra- and post-operative may be considered to minimize surgical site infection. Since no local studies examined the effectiveness of that innovation, there is a need to identify the most effective way in supplemental 80% oxygen concentration during and immediate after the colorectal surgery.

In this dissertation, a translational research was conducted to aid in developing an evidence based guideline in local Operating Theatre setting for improving surgical site infection outcomes in colorectal surgery.
A number of studies comparing administration of 80% oxygen concentration intra- and post-operative with that of receiving 30% oxygen concentration were identified and validated using critical appraisal tools. The feasibility, cost and benefit ratio were analyzed. The findings were translated and combined to develop the proposed guideline in local Operating Theatre setting. The comprehensive intervention plan, including communication plan with stakeholders, training of staffs and pilot testing will be carried out to facilitate the implementation of the innovation. The guideline on supplemental 80% oxygen concentration during and immediately after the colorectal surgery will be evaluated for its effectiveness in achieving outcome in different levels.
The Effect on Perioperative and Postoperative Oxygen Supplementation on Surgical Site Infection Rate in Colorectal Surgery

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Declaration

I declare that this thesis represents my own work, except where due acknowledgement is made, and that is has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualifications.

Signed ..............................

Ku Wun Fan
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Chapter 1: Introduction

1.1 Background

Surgical site infection, a frequently found postoperative complication of major surgery, increases the risk of patient morbidity and mortality. Although the complication is often considered to be relatively minor, it does significantly prolong hospital length of stay and increase the healthcare cost to the patient and the institution (Kirkland et al., 1999; Bratzle et al., 2005). In addition, surgical site infection rate has become a marker for the quality international recently.

The National Nosocomial Infectious Surveillance (NNIS) system of the Centers for Disease Control and Prevention (CDC) of the United States modified the definition of surgical site infection in 1992. Surgical site infection is classified into two classes: incisional and organ/space. Incisional surgical site infection is further divided into superficial (involving the skin and subcutaneous tissue) and deep (involving fascia and muscle layers) (Mangram et al., 1999). In our hospital, we adopted this definition for surgical site infection (see Appendix 1).

Among different kinds of surgeries, major colorectal surgery is reported the highest risk of surgical site infection which is probably due to the abundant bacteria in large bowel. The surgical site infection prevalence rate is ranged from 3% to 30% for colon and rectal surgery (Tang et al., 2001; Smith et al., 2004; Itani
et al., 2006; Anthony et al., 2011). Dellinger (2005) reported that two main factors contributed for the infection at a surgical site wound. First, it is the amount of bacteria that could access to the surgical site. With the extremely high content of bacteria found in colon and rectum, it could prone to higher risk of surgical site infection. Second, it is how strong of body immune mechanism to defense the bacteria approached during the wound-healing process within the first few hours postoperatively. Roos et al. (2003) and Babior (1978) both showed that leukocytes in our body damaged bacteria cells by using oxidative killing mechanism at the surgical site wound. In addition, under low oxygen level at the surgical site wound, the oxidative killing ability of leukocytes was significantly depressed (Babior, 1978; Allen et al., 1997), which allowed survival of bacteria and so increased the risk of infection at the surgical site. The proposed hypothesis was that increasing tissue oxygen tension perioperatively and immediate postoperatively may lead to enhance the oxidative killing capacity of neutrophil and thus reduce the rate of surgical site infection (Babior, 1978; Allen et al., 1997; Hopf et al., 1997).

Traditionally, the CDC calculated surgical site infection rates by 3 equal components: the American Society of Anesthesiologists (ASA) score, wound classification, and the length of the surgery (Culver et al., 1991). A recent risk model developed by Mu et al. (2011) improved the prediction on the surgical site
infection based on the existing data collected through National Healthcare Safety Network, a secure web-based system used by CDC. The infection rates of patients undergoing colon and rectal surgery remain high when compared to other types of surgery.

1.2 Affirming the Need

We consider an operative theatre setting in a regional hospital under the Hospital Authority in Hong Kong. Patients undergoing elective colorectal surgery are under general anesthesia. Patients usually receive 100% fraction of oxygen before intubation for 2 minutes and then oxygen concentration is titrated to be around 30-40% through anesthesia machine intra-operatively. After the surgery, patients are administrated 100% oxygen concentration for 2 minutes before extubation. In recovery room, 2L/min oxygen, which equals to 28% of oxygen, is administrated through nasal cannula for about 15 minutes and then patients are allowed to breathe ambient air with at least 95% pulse oximetry maintained. By observation in the local setting, there are 5-6 patients among 100 patients who had undergone colorectal surgery had surgical site infection. The result is supported by a local study that reported the prevalence of surgical site infection was 5.7% (Poon et al., 2009).

Because of surgical site infection, it can cause prolonged hospitalization and
substantial clinical and economic costs on institutions (Lissovoy et al., 2009; Kashimura et al., 2012). It also negatively affects patient’s quality of life. Antibiotics are often used as treatment for surgical site infection which may contribute to the antimicrobial resistance problem. The work and personal lives of patients who are suffered from surgical site infection may be seriously affected as a result of wound pain, prolonged recovery time and frequent follow-up visits. As a whole, surgical site infections not only affect the institution and individual, but also add burden on family caregivers, employers, insurers, and society.

Tissue oxygenation has indeed been identified as a factor that may reduce surgical site infection in colorectal patients (Jimenez & Wilson, 2003).

Recently, there are guidelines introduced and implemented by different organizations and institutes worldwide in order to reduce surgical site infection rate. In Hong Kong, the Department of Health (2009) established recommendations on prevention of surgical site infection. It suggested that a bundle of evidence-based interventions including prophylactic antibiotics, appropriate hair removal, alcoholic Chlorhexidine as skin disinfectant, and perioperative normothermia that are used to reduce the incidence of surgical site infection. However, there is no formal protocol in maintaining high tissue oxygen tension in colorectal patients in the local operating theatre setting. Some
randomized controlled trials (Grief et al., 2000; Belda et al., 2005; Schietroma et al., 2012) investigated the potential beneficial effect of high inspired oxygen supplement found a statistically significant reduction in surgical site infection. Previous meta-analysis (Mantaj et al., 2009) of randomized controlled trials examining colorectal surgery showed supplemental intra- and post-operative oxygen did not significantly decrease the incidence of surgical site infection. However, the randomized controlled trials included in this meta-analysis by Mantaj et al. (2009) not only focus on the colorectal patients but also including patients underwent other types of surgery such as open abdominal surgery. Based on these inconclusive results, the clinical role of high tissue oxygen tension for preventing surgical site infection remains undecided. It is essential to determine whether intra- and postoperative oxygen decrease surgical site infection specified for colorectal patients.

1.3 Objective and Significance

The objectives of this dissertation are:

1) To systematically review the current evidence regarding the effectiveness of supplemental oxygen concentration of 80% on the incidence of surgical site infection for patients who undergo elective open colorectal surgery;

2) To develop an evidence-based protocol on maintaining hyperoxia intra- and
postoperative in patients undergo colorectal surgery;

3) To assess the implementation potential of the proposed evidence-based protocol;

4) To develop implementation and evaluation plan of the proposed evidence-based protocol.

Upon successful implementation of the evidence-based protocol on maintaining hyperoxia intra- and postoperative in patients undergo colorectal surgery; there can be a number of benefits brought to the patients, staff, and the healthcare system.

For the patients undergo colorectal surgery, decrease in surgical site infection can help promote recovery time from surgery. Patients will suffer from less pain and postoperative complications after the surgery. Also, patients will spend less time in hospital in terms of hospitalization stay and number of follow-up needed, so that they can discharge home earlier and resume work sooner. In addition, shortened recovery time means lessen burden on families and caregivers, and enhance patient’s quality of life.

For the nurses, a clear and consistent protocol can help to make critical decision, prevent confusion and variations in order to decide the best patients care implementation in colorectal patients (Labeau et al., 2009). Moreover, reduce in
the hospital stay of patients will reduce the routine workload and more time can spend on literacy research for quality improvement in patient care.

For healthcare system, reduce in surgical site infection will reduce the clinical and economic costs in terms of extra medication prescribed, extra resources used in intensive care and extra resources used for re-operation if needed. Moreover, organization can have a better resources allocation and utilization of the resources.

Chapter 2: Critical Appraisal

2.1 Search and Appraisal Strategies

Inclusion criteria

Studies design should be original studies in randomized control trials. Studies must focus on the adult patients (aged 18 or above) who undergo elective open colorectal surgery. Also, studies should be comparing supplemental oxygen intraoperative with standard oxygen concentrations with no administration of supplemental oxygen during and immediate after the procedure. Moreover, defined surgical site infection should be considered as either the primary or secondary outcome.

Exclusion criteria
Studies focusing on non-colorectal-specified are excluded because colorectal patients are the main focus in this study. Also, studies on hyperbaric oxygen administration are also excluded, because the aim of the current dissertation is to investigate the hyperoxia or supplemental oxygen that could only be obtained at 1 atmosphere pressure. In addition, laparoscopic or emergency surgeries are excluded.

**Electronic database choices**

Five electronic databases are used. They are Pubmed, CINAHL plus (1974 to 2013), Embase Classic and EMBASE, The Cochrane library, and MEDLINE. There was no limitation on the period of the searching articles as well as on language used.

**The use of keywords**

The use of keywords divides into three categories which including infection, type of surgery and type of intervention. The keywords of infection included “wound infection”, “postoperative complication”, “wound complication” and “surgical site infection”. The keywords of the type of surgery were “colon”, “rectum” and “colorectal”. The keyword of the type of intervention was “oxygen”.

**Screening process**

The studies retrieved from the electronic databases were firstly screened on
the basis of the inclusion and exclusion criteria for their eligibility to the titles and abstracts and then to the full-texts manually. In addition, reference lists of all relevant studies retrieved were manual searched.

Data Extraction

Dates were extracted in the form of tables of evidence, which helped to examine and categorize date. Characteristics of the studies and interventions are presented in the Tables.

Quality Assessment

Methodology checklists for randomized controlled trials (see Appendix 2) developed by the Scottish Intercollegiate Guidelines Network (SIGN) in May 2012 were used for quality assessment. The internal validity of the selected studies was evaluated according to the checklist. Levels of evidence were rated in accordance with the overall quality of the studies.

2.2 Results

A total of 384 relevant articles yielded from the electronic searches on August 2013. Limited to randomized controlled trials, 86 copies of relevant study were retrieved. One study was produced by manual searches of reviewing reference lists of relevant studies. The titles and abstracts of those 87 copies of relevant studies were screened. Duplicated studies were eliminated and the studies
were examined with reference to the inclusion and exclusion criteria. Only 4 studies were selected for evaluation after the abstract review (see Figure 1.).

2.3 Summary and Synthesis

2.3.1 Summary of data

For the subject characteristic, all studies included patients underwent elective open colorectal surgery that aged between 57 and 71 but they all excluded patients with serious malnutrition, a serum albumin concentration below 30g/L, a leukocyte count less than 2500 cells/mL, and weight loss exceeding 20-30% in the previous 3 months. All four studies Three studies (Greif et al., 2000; Belda et al., 2005; Schietroma et al., 2012) excluded those scheduled for minor colon surgery time less than 1 hour and patients had a recent history of fever, or existing signs of infection but one (Mayzler et al., 2005) did not disclose the details. Three studies (Belda et al., 2005; Mayzler et al., 2005; Schietroma et al., 2012) excluded patient was known diagnosed with human immunodeficiency virus infection or preoperative immunosuppressive therapy but not mentioned in the other study (Grief et al., 2000). Two studies (Belda et al., 2005; Mayzler et al., 2005) excluded patients suffered from diabetes mellitus but the other two (Greif et al., 2000; Schietroma et al., 2012) did not mentioned. Three studies (Greif et al., 2000; Belda et al., 2005; Schietroma et al., 2012) included patients with history of
respiratory disease but one (Mayzler et al., 2005) excluded patients with chronic obstructive pulmonary disease. Only one study (Mayzler et al., 2005) excluded patients with morbid obesity which body mass index larger or equal to 35 but not the other three studies (Greif et al., 2000; Belda et al., 2005; Schietroma et al., 2012). One study (Greif et al., 2000) excluded patients with bowel obstruction but not the other three studies (Belda et al., 2005; Mayzler et al., 2005; Schietroma et al., 2012).

For outcome measure, all studies measured outcome on the incidence of defined surgical site infection. However, the definition of surgical site infection various among four studies. One (Greif et al., 2000) used positive pus culture collected at wound site within 15 days after the procedure for the confirmation of surgical site infection. One (Belda et al., 2005) defined surgical site infection according to the CDC definitions for superficial incisional, deep incisional, and organ/space surgical site infection (Mangram et al., 1999), with only infections within first 14 days after procedure were included. One (Mayzler et al., 2005) defined surgical site infection to be presence of wound erythema with pain and purulence within 30 postoperative days. The remaining one (Schietroma et al., 2012) defined surgical site infection into 4 grades according to signs such as induration, erythema, pain, and the amount of contaminated fluid presented.
For measuring tools, all studies measured the surgical site infection by calculating the percentage of surgical site infection rate. Three studies (Greif et al., 2000; Belda et al., 2005; 2005; Schietroma et al., 2012) showed a significant reduction effect on surgical site infection rate and one (Mayzler et al., 2005) showed a reduction in surgical site infection with an insignificant p-value. This may due to the small sample size in the study which results in an underpowered study. A total of 898 patients were enrolled in these studies, with 452 were randomized to supplemental 80% oxygen group and 449 were randomized to control group. The pooled infection rate (Table 1) in the intervention group was 9.3% while the infection rate was 17% in the control group. The pooled rate of surgical site infection among the studies is presented in Table 1. By using a random-effects model, the combined Odd Ratio (OR) was 0.4918 and the 95% confidence interval is 0.3267 to 0.7405 and are located to the left of “1”, suggesting a beneficial effect from intervention (80% oxygen) versus control (30% oxygen) (Figure 3). The $I^2$ value for pooled estimate is 0% which shows no statistical heterogeneity detected (p=0.96) (Table 2).

In addition, ASEPSIS score was used as measuring tool for wound healing characteristics evaluation in two studies (Greif et al., 2000; Belda et al., 2005), while higher ASEPSIS score indicated poorer healing and a greater likelihood of
infection in study of Greif et al. (2000) but a daily score larger or equal to 20 was also considered as infection in the study of Belda et al. (2005).

Three studies (Greif et al., 2000; Belda et al., 2005; Schietroma et al., 2012) included, one study (Mayzler et al., 2005) did not include data on mortality. The mortality rate among the remaining three studies is presented in Table 3. These studies included 433 patients in intervention group and 430 patients in control group which add up to 863 patients in total. The mortality rate was 0.23% and 2.33% in intervention and control group respectively. By using random--effects model, the combined Odd Ratio (OR) was 0.178 and the 95% confidence interval is 0.0392 to 0.8113 and are located to the left of “1”, suggesting a beneficial effect from intervention (80% oxygen) versus control (30% oxygen) (Figure. 4). Statistical heterogeneity was not detected with I² equals to zero (p=0.993) (Table 4).

The table of summary of data of the selected studies is shown in table 5.

2.3.2 Summary of Quality Assessment

In general, all the studies had set an appropriate and clear research question, in which the subjects’ characteristics such as medical history, risk factors and infection status were compared. The only difference between the intervention and control groups was the oxygen concentration administrated intra- and
postoperative. No statistically difference was noted between the intervention and control groups.

All studies had stated the procedure to assign subjects to either intervention group or control group to be randomized. Two studies (Greif et al., 2000; Belda et al., 2005) used a computer-generated random-numbers series. One study (Mayzler et al., 2005) allocated treatment groups by using closed envelopes, without disclosed the exact method of generating the series when allocating the treatment groups. One study (Schietroma et al., 2012) only stated subjects assignment to treatment groups randomly without disclosing any concrete details on the method of randomization. Although there may be an appropriate technique that was used for randomization, not enough information was provided for better judgment.

For concealment adequacy, three studies (Greif et al., 2000; Belda et al., 2005; Mayzler et al., 2005) used sealed envelopes for allocation concealment, which only one study (Belda et al., 2005) mentioned opaque sealed envelopes was used. Two studies (Greif et al., 2000; Belda et al., 2005) also mentioned using of cardboard shield to cover the anesthesia machine and gas monitors both in the operating theatre and post-anesthesia care unit. One study (Schietroma et al., 2012) did not describe methods for allocation concealment. Using sealed envelopes is considered as adequate allocation concealment method.
For subject blinding, all studies stated that both subjects and the outcome assessors were blinded to treatment assignment. Only one study (Mayzler et al., 2005) mentioned the blinding of investigators to subjects but not the other three studies (Greif et al., 2000; Belda et al., 2005; Schietroma et al., 2012). There were no subjects dropout from the study in three selected studies (Greif et al., 2000; Mayzler et al., 2005; Schietroma et al., 2012) while one study (Belda et al., 2005) resulted with calculated dropout rate in the treatment and control group was 1.33% and 4.67% respectively.

For analysis, one study (Greif et al., 2000) stated use of intention-to-treat analysis. Belda et al. (2005) stated reasons for the reasons for the dropouts, including incomplete date, low preoperative albumin and unexpected change to laparoscopic surgery after induction of anesthesia and a sensitivity analyses was performed to include all subjects. The other two studies (Mayzler et al., 2005; Schietroma et al., 2012) used comparative univariate analyses such as the Fisher’s exact test to ensure all subjects were analyzed in the groups which they were originally assigned to.

For power calculation, two studies (Greif et al., 2000; Belda et al., 2005) reported the method of sample size calculation used. Power calculation was not performed in the other two studies (Mayzler et al., 2005; Schietroma et al., 2012).
For level of evidence, two studies (Greif et al., 2000; Belda et al., 2005) were rated as “++” and two studies (Mayzler et al., 2005; Schietroma et al., 2012) were rated as “+”.

The internal validity and overall quality of the four selected studies are showed in Table 6 and Table 7 respectively.

2.3.3 Synthesis of Data

With reference to the results of critical review of the selected RCTs, a beneficial effect on reducing the incidence of surgical site infection was demonstrated in the administration of 80% oxygen concentration intra- and post-operative. The evidence suggested that it can be considered as a supplemental therapy in routine intra- and post-operative care for patients undergo colorectal surgery in view of no related intervention in current practice. Meanwhile, there was some useful information retrieved from the critical appraisal for developing an evidence-based protocol.

In the four included studies, patient populations were generally homogeneous. They represented a spectrum of patient undergone elective open colorectal surgery that resembles those in local settings. Demographic characteristics such as age of the subjects across studies and the severity of illness as measured by ASA score were similar.
Regarding reduction rate of surgical site infection, the effect size was from 5% to 12.8%. Three studies (Grief et al., 2000; Belda et al., 2005; Schietroma et al., 2012) showed a significant effect of supplemental 80% during and immediately after the surgery on the rate of surgical site infection. On contrast, Mayzler et al., (2005) did not demonstrate a significant beneficial effect from using a high oxygen concentration supplement with no nitrous oxide in the intervention group. Also, the sample size was very small, resulting in an underpowered study. When the results of all included studies are combined, it is found that the intra- and immediate post-operative supplemental of 80% oxygen concentration reduced the risk of surgical site infection with a statistically significant finding (p= 0.0007).

Administrating high concentration of oxygen can result in postoperative pulmonary absorption atelectasis (Rothen et al., 1995). However, no significant increase in pulmonary complications was founded in the included studies. Moreover, a recently study by Akca et al., (1999) showed that the administration of high concentration of 80% oxygen did not worsen lung function. The study compared the lung volumes, the incidence and severity of postoperative atelectasis and alveolar gas exchange among patient undergone colon resection with administration of 30% and 80% oxygen intra- and post-operative. Therefore,
Akca et al., (1999) recommended use of supplemental 80% oxygen intra- and post-operative not only because of the beneficial effect of high concentration oxygen but also of no harmful effect. Hedenstierna G., (1998) and Edmark et al., (2003) also argued that the use of 100% oxygen instead of 80% oxygen increase the postoperative pulmonary complications.

2.3.4 Recommendations

Type of Surgery: Patients undergo elective open colorectal surgery is recommended. (Greif et al., 2000; Belda et al., 2005; Mayzler et al., 2005; Schietroma et al., 2012) (level of evidence “++”, “++”, “+” and “+” respectively).

Patient characteristics: Adult aged 18 or above. ASA score I, II and III only (Greif et al., 2000; Belda et al., 2005; Schietroma et al., 2012) (level of evidence “++”, “++”, and “+” respectively).

Intra-operative

Characteristics of oxygen: The administration of 80% oxygen concentration is highly recommended during the surgery (Greif et al., 2000; Belda et al., 2005; Mayzler et al., 2005; Schietroma et al., 2012) (level of evidence “++”, “++”, “+” and “+” respectively).

Gas mixture/actual oxygen concentration used: Air/oxygen mixture is highly recommended (Belda et al., 2005) (level of evidence “++”) and nitrogen/oxygen
mixture also recommended (Greif et al., 2000; Schietroma et al., 2012) (level of evidence “++” and “+”).

Post-operative

Characteristics of oxygen: The administration of 80% oxygen concentration is highly recommended during the surgery (Greif et al., 2000; Belda et al., 2005; Mayzler et al., 2005; Schietroma et al., 2012) (level of evidence “++”, “++”, “+” and “+” respectively).

Gas mixture/actual oxygen concentration used: Air/oxygen mixture is highly recommended (Belda et al., 2005) (level of evidence “++”) and nitrogen/oxygen mixture also recommended (Greif et al., 2000; Schietroma et al., 2012) (level of evidence “++” and “+”).

Length of oxygen administration: Administration of 80% oxygen is recommended from 2 hours (Greif et al., 2000; Mayzler et al., 2005) (level of evidence “++” and “+”) to 6 hours (Belda et al., 2005; Schietroma et al., 2012) (level of evidence “++” and “+”). Patients breathe ambient air afterward with pulse oximetry at least 94% is recommended (Greif et al., 2000; Belda et al., 2005; Mayzler et al., 2005; Schietroma et al., 2012) (level of evidence “++”, “++”, “+” and “+” respectively).

Mode of administration: A non-rebreathing face mask with a reservoir is
recommended for oxygen administration (Greif et al., 2000; Belda et al., 2005; Mayzler et al., 2005; Schietroma et al., 2012) (level of evidence “++”, “+++”, “+” and “+” respectively).

In conclusion, administration of 80% oxygen concentration intra- and post-operation has beneficial effect on the incidence of surgical site infection in the patient undergoing elective open colorectal surgery and health care professionals should adopt and implement this in daily practice whenever available. The optimal time for administration of oxygen should be 2-6 hours postoperatively through a non-rebreathing face mask with a reservoir which could allow for ambient air to maintain a pulse oximetry at least 94%.

Chapter 3: Implementation Potential

In the review, it is shown that administration of supplemental oxygen intra- and post-operatively is an effective intervention to reduce surgical site infection for patient undergoing colorectal surgery. This benefit can be potentially transferred into Operating Theatre Services Department (OT) of the local setting in a University teaching hospital in Hong Kong. The transferability of the findings from the reviewed studies and the feasibility of implementing the proposed innovation will be discussed. Also, the cost-benefit ratio of the innovation will be
examined.

3.1 Target audience and setting

The target audience is patients who are undergoing elective open colorectal surgery in a local university teaching hospital in Hong Kong. There are 42 hospital beds located in 2 surgical wards for taking care of colorectal patients in local hospital. Colorectal surgical patients are scheduled for surgery in two whole day and a half day sessions per week. The types of operations are various, which mainly include open or laparoscopic lower anterior resection, hernia repair, bowel resection and stoma formations.

3.2 Transferability of the Findings

3.2.1 Comparisons of Setting and Audience

As no specific administration of supplemental oxygen intra- and post-operation for patients undergoing colorectal surgeries currently available, a clinical guideline for practice should be developed. The guideline should be based on recommendations from this clinical area and it should be tailored for hospitalized adult patients with colorectal disease who are eligible for colorectal surgery.

To assess whether this clinical guideline suit in the local Operating Theatre, a comparison of the basic patient demographic characteristics and selected outcomes between the local hospital and the selected studies was performed
(Appendix 3). The data used was conducted by Poon et al. (2009) in the same local hospital setting from January 2002 to December 2006.

Male patients out-numbered female patients in all studies, in which gender distribution is more or less the same in all studies with around 6:4 male to female ratio. Regarding the age, patients in all studies were between fifty and seventy. For the patients who underwent open elective colorectal surgery in local hospital, the male to female ratio was around 6 to 4 and the mean age was 68, which were similar to the study population (Poon et al., 2009).

All four studies considered the physical status scores by using American Society of Anesthesiologists (ASA) as a grading system for preoperative overall health of the surgical patients that is based on five classes from I to V. The patient’s health condition becomes more critical when the class is higher as shown in Appendix 4. With high operative risk with ASA class 3 and 4 ranged from 6 to 30% in two studies (Grief et al., 2000; Belda et al., 2005) while 57% patients were found to be in ASA class 3 in one study (Schietroma et al., 2012). However, one study (Mayzler et al., 2005) excluded those patients classified into ASA class 3 or 4. There were 22.9% patients from local hospital found to be in ASA class 3 and 4 (Poon et al., 2009), which suggested that the recruited patients were comparable in terms of severity of physical status.
Regarding to the perioperative blood transfusion, three studies (Grief et al., 2000; Belda et al., 2005; Mayzler et al., 2005) showed that there were 0 to 31% patients needed blood transfusion during the procedure while one studies (Schietroma et al., 2012) did not disclose the details. There were 8.2% patients in local hospital needed blood transfusion perioperatively (Poon et al., 2009). The data confirmed the homogeneity between the studies and the local setting.

As for operating time, the mean duration was from 135 to 195 minutes in three studies (Grief et al., 2000; Mayzler et al., 2005; Schietroma et al., 2012) while one study (Belda et al., 2005) did not mention the operating time used. The mean operating time in local setting was 146 minutes (Poon et al., 2009). This suggested the homogeneity date between the studies and the local setting.

For the outcomes, the surgical site infection rate of local hospital using 30% oxygen concentration was 7.7% (Poon et al., 2009) and that of the studies included was from ten to thirty by control group which patient receiving 30% oxygen concentration. Although the outcome with patient from local hospital was a little bit lower than those reported for the patients receiving 30% oxygen concentration group (control) during the procedure in all four included studies, but it was close to the lower range of the population in all four selected studies (Grief et al., 2000; Mayzler et al., 2005; Belda et al., 2005; Schietroma et al., 2012).
With regards to the mortality rate, it was about one to five percent for the patients who receiving 30% oxygen concentration (control group) in the three studies (Grief et al., 2000; Belda et al., 2005; Schietroma et al., 2012). One study (Mayzler et al., 2005) did not mention the mortality rate. In local hospital, the mortality rate was 1% (Poon et al., 2009) which supported the homogeneity population between the studies and the local setting.

Concerning the length of hospital stay, the mean duration for local hospital was 8 days (Poon et al., 2009). It was 10 to 12 days for the patients who administrated with 30% oxygen concentration group (control) in the two studies (Grief et al., 2000; Belda et al., 2005). Although the length was shorter in local setting date, the difference was rather small and therefore the discrepancy could not necessarily be interpreted as true differences between settings.

3.2.2 Philosophy of Care

The philosophy of care underlying the innovation is also an essential determinant of successful transferability of the findings. Both reviewed studies shared similar objectives such as to improve and maintain patient’s quality of life, to help them to prevent the incidence of wound infection after the surgery in order to shorten the length of hospitalization as well as maintain optimum resource utilization of available resources. Holistic and person-centered approach in
combination with evidence-based practice is adopted to address the needs of the patients, in order to achieve the highest level of patient outcomes.

“Helping people stay healthy” and “People-centered care, Professional service…” are the mission and the values of local government hospital. “Build people-first culture” and “Maintain financial sustainability” are two of the strategic priorities adopted for local government hospital to achieve the corporate vision in Hong Kong (The Hong Kong Hospital Authority, 2013). In the proposed setting, health care professionals have mostly adopted the vision and missions at work and are willing to introduce new innovations aiming to provide quality client-centered service. The philosophies of care in both the Western community and local setting are elementally sharing the same rationale in reducing surgical site infection rate in colorectal patients.

3.2.3 Sufficiency of Clients Benefit from the Innovation

Staff and organizations structure involved is also a vital factor for transfer of positive research findings. All included studies shared same manner in patient care that anesthesiologists mainly responsible for the physical status of patients pre-, intra- and postoperatively which mainly under care in Operating Theatre. And the surgeons mainly took care of the operating procedures involved and the time when patients transferred back to destined wards. Such multidisciplinary approach
of patient care is also adopted in local Operating Theatre settings. Based on observation, patients underwent elective open colorectal surgery accounts for 70% of the total annual elective colorectal surgery, which including both open, laparoscopic colorectal surgery. There are two and a half day sessions per week for colorectal operation in local hospital, which 240 cases could be performed annually. It is projected that the number of patients who will benefit from the proposed change is nearly one hundred and seventy per year. Since the population of patients who undergoing colorectal surgery is likely to remain more or less the same, it is justified that the proposed innovation will have a positive impact on a significant proportion of the patients undergoing elective colorectal surgery.

3.2.4 Time Schedule for Implementation and Evaluation

In the preparation phase, three months will be needed for the obtainment of approval from administrative level and two months will be needed for forming of committee for protocol development. After that, one months will be needed for the promotion of the proposed innovation via email and circulars on the use of 80% oxygen concentration intra- and post-operatively on patient undergoing elective open colorectal surgery to the concerning parties including surgeons, anesthesiologists, nurses in ward and Operating Theatre. The implementation of the intervention will last for three months. The evaluation will last for one month.
and one month for data entry and analysis.

3.3 Feasibility

3.3.1 Freedom on Implementation

Regarding the feasibility of a program, staff, skills, equipment available and time should be considered. It is feasible to implement the proposed innovation in my practice. However, it is necessary to seek approval from the departmental head of the service before implementation. It is not likely to be difficult to gain support for the innovation from the department head of service by showing potential benefits. In addition, the proposed supplemental oxygen intra- and post-operatively for patients undergoing colorectal surgery is consistent with the priority strategic areas of HA in the next four years that managing the introduction of new technologies or practice into local services is the key to enhancing the quality of care (The Hong Kong Hospital Authority, 2012).

3.3.2 Interference with Current Functions

Incorporation of the proposed program into the services of the in local hospital will not interfere with the existing functions of nurses in the ward or in Operating Theatre or that of anesthesiologists or surgeons. The proposed intervention involves an additional procedure of administration of non-rebreathing mask with 80% oxygen concentration immediately after the procedure for 2 hours
instead of 2 Liter/minutes oxygen administration for half hour. Although this only change in the devices used, the high-flow of 80% oxygen concentration from non-rebreathing mask still cause some discomfort for patients, such as dry-mouth. Nurses in post-anesthetic-care-unit (PACU) need extra patience and explanation to relief patient’s discomfort. On the other hand, it may increase some workload of nursing staff if taking care of multiple patients in a time.

3.3.3 Administration support

Local setting is a regional hospital providing education facilities for a local university and so local hospital is a training center for health care professionals. The organization is performing clinical trials frequently in collaborating with the university. The atmosphere of the hospital encourages and introduces new evidence-based interventions and programs for the provision of quality patient services. In addition, the Chief of Service (COS) and Department Operation Manager (DOM) of Operating Theatre have been supportive in utilization of research results into current exist services for better patient outcomes.

3.3.4 Consensus among Staff

The efficacy of administration of 80% oxygen concentration intra- and post-operative had been scientifically supported. Although it may cause some extra workload for the nursing staff during the implementation process, it should
be offset by the clinical benefits. Besides, the nursing staffs working at the local hospital operating theatre has strong team spirit and share same mission. Establish a working group is proposed to facilitate the communication during the implementation of the innovation. The team member of the working group is suggested to include a surgeon, an anesthesiologist and two nurses. Support from those three parties is essentially important before the implementation of the innovation. New interventions and programs such as normothermia maintaining within the operating theatre to reduce the surgical site infection in regard to colorectal patients have been introduced in the department recently. The acceptance of the new interventions in my department is good from past experience. In order to tackle the potential frictions and collect comments from staff with different view and opinions on the proposed innovations, an enquiry period should be provided.

3.3.4 Staff development/Skills/Equipment needed

With regarding in staff skill availability, the nurses in ward are responsible for providing education on the innovation preoperatively and the nurses in PACU are responsible for examination of any contraindication to administration of supplemental high concentration oxygen by observation and the vital sign presented in postoperatively.
A patient undergo major surgery under General Anaesthesia will transfer to post-anaesthetic care unit for observation. Under normal circumstance, patient can meet discharge criteria such as controllable postoperative pain, nausea and vomiting as well as stable vital sign, within one hour after surgery in post-anaesthetic care unit. The proposed innovation only involves using non-rebreathing mask with 80% oxygen concentration 2 hours post-operatively instead of nasal cannula with 2 liter/minute after the surgery. It is therefore patient will stay in post-anaesthetic care unit for 2 hours before discharge to ward in order to minimums the workload in surgical wards. No special training for the administration method by using non-rebreathing mask is need for the nursing staff but educational sessions covering methods for administration of oxygen using non-rebreathing mask will be provided. A guideline with relevant photos on administration of non-rebreathing mask would be provided for staff training.

In terms of equipment, non-rebreathing mask and educational leaflets will be the main commodities used. There are no new items needed for the innovation. However, non-rebreathing mask should be ordered for extra amount from the Consumable Unit according to the needs. Related educational leaflets will be designed by the working group and will be provided both in concerned wards and operating theatre. Besides, evaluation forms are also needed for better
improvement.

In addition, a proper evaluation should be performed to assess the effectiveness of the program. Details of the implementation strategies and evaluation plan will be discussed in Chapter 4.

3.4 Costs-Benefit Ratio of the Innovation

To ensure the target population can receive the proposed innovation with maximum health care benefit by experiencing least health care risk and cost, it is necessary to conduct a cost-benefit ratio analysis. Moreover, material and non-material costs should also be included to assess those impacts on the health care system (Polit & Beck, 2004).

3.4.1 Potential Risks

The included studies for review showed a positive reduction on the surgical site infection by administrating 80% oxygen concentration intra- and post-operative when comparing using 30% oxygen concentration for the patients underwent elective open colorectal surgery. Some argued that patients received high concentration of oxygen may cause increase in postoperative oxygen requirements or even cause postoperative pulmonary atelectasis. However a previously research analysis a subgroup of 100 patients showed that using intraoperative FiO2 higher than 0.9 was not associated with increase oxygen
requirement and suggested that it may be reasonable to use high inspired oxygen in surgical patients (Mackintosh et al., 2012). Another subgroup analysis of 30 patients revealed that supplemental oxygen did not worsen pulmonary function or cause atelectasis as supported by using chest radiographs or computed tomographic scans (Akca et al., 1999). In addition, a subgroup analysis of 231 patients showed that supplemental oxygen halved the incidence of postoperative nausea and vomiting (Greif et al., 1999). To conclude, the target population will not be exposed to any potential risks during the implementation of the innovation.

3.4.2 Potential Benefits

For the implementation of administration of supplemental oxygen intra- and post-operative guideline, the major benefit is a reduction in surgical site infection, one of the most serious common complications of surgery. Generally, guideline is the evidence-based for quality of care improvement. However, different people have different definition on quality, it is therefore setting up an evidence-based guideline not just to minimize the definition gaps among multidisciplinary but also to control practice variation and optimizes care delivery within organization (Woolf et al., 1999). In addition, Woolf et al. (1999) continued to point out that clinical guideline development usually based on the needs for under-recognized health problems, neglected patient population or high risk groups. Therefore,
newly developed clinical guideline focus on the public good which can promote distributive justice, advocating better delivery of services to those in need. Moreover, according to Grimshaw et al. (2004), guideline always regards as the standard of care provided by healthcare professions; it may be effective in improving efficiency and optimizing value for money in a healthcare system. On the other hands, any inappropriate use of guideline, non-adherence without reasonable justification may lead to legal actions. Staff concerned may be anxious and frustrated if lack of administration support. Patients, healthcare professionals and the healthcare systems will be benefit from the proposed innovation.

With regarding the target patients, they will be benefit from the innovation in several ways. Complications associated with surgical site infection after surgery include diminished quality of life, prolonged hospitalization stay and increased morbidity and mortality (de Lissovoy et al., 2009; Kashimura et al., 2012). The proposed supplemental oxygen administration intra- and post-operatively innovation can reduce the surgical site infection rate so as the length of hospitalization stay and the morbidity and mortality rate with increase quality of life in target patients. Grief et al. (2000) pointed out that patients may complaint the mouth-dryness and discomfort during the period using the non-rebreathing facemask with high flow of oxygen given. Initially, the proposed intervention may
increase the workload of nursing staff. However, the benefits of the innovation to patients and nurses will become apparent later.

3.4.3 Estimated expenditure

Concerning healthcare expenditure, the actual costs of implementing of proposed innovation are not readily identifiable since costs are distributed across many aspects of nursing and clinical care. However, the associated expenses can be divided into two main portions: material expenses and non-material expenses.

Non-material expenses include the expenses for all nurses who are involved in the project (See Appendix 7). The total time spent on the program is estimated as 565 hours as in Appendix 7.

This includes one APN acts as program supervisor and two nursing staff act as program coordinators. There are 80 nurses in Operating Theatre provide direct care in perioperative period as usual and 4 nurses from wards for preoperative explanation the details and for linked-person in this proposed program. All of them will be relieved from normal duty in groups to attend a one-off training session which last for 1.5 hours prior to the program commencement. Additional time spent by them on each recruited patient is estimated to be 0.5 hour. Two nurses are act as project coordinator which responsible for 10 meets those 2 hours for each meeting. Also, they organize staff training sessions which 2 identical
sessions with each last for 1.5 hours and monitoring the progress of the proposed program. Therefore, the total time spent by nurses in the programme will be 438 hours. When the time spent by nurses converted into monetary terms, it accounts for about 40% of the total project expenditure (Appendix 8).

The material expenses include the non-rebreathing mask and the photocopies for leaflet and evaluation form. The current practice is maintaining 30% oxygen concentration during the procedure and giving 2 liter/minutes oxygen through oxygen cannula for 30 minutes postoperatively in PACU. When comparing the current practice with the proposed intervention, it is found that three times expected material expense more needed for a patient of proposed intervention. The material expense on current practice is $1.45/patient while that is $4.5/patient for the proposed intervention (Appendix 5 & 6).

In the above expenditure calculation, some “hidden” costs are excluded. First of all, the venue for meetings, computer accessories and statistical software this is readily available in the department. Secondly, the time spent by Operating Theatre managers, surgeons and anesthesiologists are excluded. It is because their participation varies over the implementation period and is difficult to quantify.

Benefit of administration of supplemental oxygen perioperatively results from direct reduction in surgical site infection rate. Coello et al. (2005) calculated
that the extra cost for each incisional surgical site infection was HK$28,939 and HK$42,917 for each Space/Organ surgical site infection. Reduction in surgical site infection rate was observed in all the included studies, ranging from 33% to 54%, with a mean percentage reduction of 43.5%. If cost savings are calculated as the associated reduction in surgical site infection in 170 patients in a year, adjusting for a surgical site infection rate of 3.5%, the most conservative assumption will still yield a cost saving of HK$273446 for reduction in the surgical site infection. In such regards, although the start-up cost for administration of supplemental oxygen perioperatively seems to be huge, the annual healthcare money saving can still potentially amounts to HK$159714.5 per year (Appendix 9, 10 & 11).

In conclusion, administration of supplemental oxygen perioperatively had great potential to be implemented in local hospital setting. The benefit that it brings out-weights the risks and costs of the program.

Chapter 4: Implementation Plan

4.1 Communication Plan

4.1.1 Identification of Stakeholders

This protocol requires the entire cooperation of the staff of the Operating
Theatre, anaesthetists and Infection Control Unit of the local hospital. Therefore the stakeholders and potential users involved can be classified into administrative, managerial and operational levels.

At the administrative level, the Departmental Operation Manager in the Operating Theatre and the Chief of the Service of Anaesthesia are key persons for final decision making who offer resources and give approval to carry out the innovation. Since the aim of the protocol is to reduce the rate of surgical site infection, it is therefore Senior Nursing Officer from the infection Control Unit in local setting be another stakeholder in the innovation.

The managerial level consists of Ward Manager, Advanced Practice Nurses and Nursing Officers of Colorectal Surgery and Operating Theatre. Ward Managers control the human and financial resources used in the innovation. In addition, they monitor and assist the whole progress in implementation change. The Advanced Practice Nurses and Nursing Officers are those with advanced clinical experiences, knowledge and skills. They are responsible to facilitate, supervise and review the implementation of new innovation and provide education and training to all those involved in the implementation.

Anaesthetists, the frontline nurses in the Operating Theatre, in Colorectal Surgery Unit and in out-patient clinic are the stakeholders at the operational level.
Anaesthetists are another stakeholder as they are responsible to determine whether the patient is suitable for undergo the new implementation and help patient recruitment. They also provide treatment plans pre-, intra- and post-operatively. Doctors in the Colorectal Surgery are responsible to diagnose suspected surgical site infection within 30 days postoperatively and provide adequate treatment. Therefore, it is vital to gain supports from both anaesthetists and doctors in colorectal surgery department for the innovation. Nurses in Operating Theatre are responsible to carry out the new evidence based guideline. Nurses in ward and in clinic helps to collect patient data and questionnaire. The evidence based guideline would be provided for their reference in order to facilitate a better understanding of the new innovation.

4.1.2 Communication Process and Strategies

In order to obtain a well-planned program, the time frame for different tasks will be stated in a Gantt chart (Appendix 13) and will be shown to all staffs. For communication process, one month will be spent on obtaining the approval from managers, Chief of the Service and the Infection Control Unit. Another one month will be used to gain support and feedbacks from the nurses and anaesthetists, and four identical briefing sessions on the proposed innovation will be provided. Meanwhile, promotion of the proposed program will be started at the same time.
and will last for two months.

First of all, the Departmental Operation Manager in Operating Theatre and Chief of Service of Anaesthesia will be approached. The innovation proposer will make a proposal comprising the significance of the existing problem, research findings stressing the need of administration of 80% oxygen in Chapter 1; summary of guideline (Appendix 12), implementation potential, and outline of the budget, benefits of the plan (Appendix 5-11), time frame, the proposed number and roles of staff involved. After gaining support from the Departmental Operation Manager in Operating Theatre, the Chief of Service of Anaesthesia will be informed by the Departmental Operation Manager. The reason for implement the protocol, the aim and objectives of the protocol and how we carry out the innovation would be explained. The Departmental Operation Manager of the Operating Theatre and the Chief of Service of Anaesthesia will act as the coordinators in which they will lead and coordinate different working units, allocate manpower and resources, identify obstacles, and provide solutions in meetings.

The Ward Managers will be invited to join the meetings with Departmental Operation Manager in order to understand the importance of innovation for change and familiarize with the blueprint of the program. The managers in
Operating Theatre are responsible to communicate with the Senior Nursing Officer from the Infection Control Unit in the local hospital. Presenting the data and relationships among maintaining high oxygen fraction intra- and post-operative, colorectal patients and surgical site infections, Infection Control Unit would support the effect of maintaining high oxygen fraction intra- and post-operative in reducing the surgical site infection. On the other hand, the Departmental Operational Manager in Surgery and Ward Manager of the Colorectal Surgical Unit are contacted. The purpose of the protocol, the beneficial aspects including reduce the rate of surgical site infection, shortening the length of hospitalization and better patient outcome will be introduced. The managers in wards are responsible for teaching and meetings with frontline staffs for feedbacks comments.

To enhance the smooth running of the innovation, four identical briefing sessions will be held after “Day-shift” with 1.5 hours duration time for frontline nursing staff and anaesthetists. According to Ploeg et al. (2007), a small group education session with social interaction among colleagues is a key facilitator for guideline implementation. All nurses in the operating theatre are required to attend. The nurse representatives from colorectal surgery ward and from the out-patient clinic are invited. The evidence-based practice guideline and the role of staffs
would be introduced. Also, the importance of carrying out the program and the importance of the contribution of the staffs will be included in the briefing sessions. The guideline will be distributed to all frontline anaesthetists and nurses. A copy of guideline will be kept in Post-Ane...
improvement. In order to accelerate the communication among the stakeholders, a monthly meeting would be held and emails would be disseminated to acknowledge the progress of the protocol implementation. Time frame of the program is shown as Gantt chart in Appendix 13.

4.2 Pilot Study Plan

4.2.1 Objectives

The pilot test determines the feasibility of the proposed change (Pilot & Beck, 2014). It is essential to pre-testing the intervention and assesses the realistic and workable of the protocol in the local setting.

4.2.2 Target Population

The target population will be adult who undergo open colorectal surgeries. The selection criteria will be the same as set out in the clinical guideline. There are sessions on every Tuesday, Thursday and the A.M. session on Friday in the local department, which approximately 4 general open colorectal cases excluding laparoscopic surgery per week.

All nurses in theatre and anaesthetists will also be involved in the pilot test.

4.2.3 Outcome Measures

Outcome measures in pilot study are rate of surgical site infection, the patients’ opinions and satisfaction level of the program. In the meanwhile, staff
acceptance, satisfaction and level of knowledge to the new guideline are also measured.

4.2.4 Design and Data Collection

The pilot test would be launched after the adaptation period with all staff attending the briefing sessions. It will be lasted for 3 months, which 2 months for intervention and 3 months for the evaluation as indicated in Appendix 13.

At this time, the staffs are expected to have a certain level of understanding about the proposed protocol and be able to follow the protocol. The working committee will act as the auditors to conduct the pilot plan. An audit form (Appendix 16) with the content equivalent to the protocol would be served as the outcome measures to assess the acceptance of the protocol and behavioural changes. The auditor would stay within the theatre throughout the operation, from intraoperative to postoperative period. The auditor would observe the interventions provided by the staff intra- and post-operatively. Each action taken that corresponds to each item of the audit form would be given a “Tick” and a remark with explanations would be provided for any events different from the audit form. After the patient discharge from Post Anaesthetic Care Unit, staff would be asked for their comments on the protocol and the practical problems they have to encounter.
According to the local hospital guideline, the Infection Control Unit will follow patients by observing the condition of surgical wound for 30 days postoperatively. The data of surgical site infection development, signs and symptoms, grade of infection, the length for hospitalization, the re-admission rate and other complications associated with surgical site infection will be gathered by Infection Control Unit.

4.2.5 Evaluation of Pilot Plan

Recruitment will be examined by the clients’ dropout rate and the compliance to the intervention. Patients who refuse to join or quit the program will be interviewed for reasons. Patients will be asked to fill in a satisfaction questionnaire (Appendix 15) about their opinions on the satisfaction level of the program in the out-patient clinic 30-day postoperatively.

The compliance of nurses with the guideline will be assessed by audit form (Appendix 16). On the other hand, nurses and anaesthetists will be asked about their comments on their self-perceived skill and confidence level in implementing the program. The level of satisfaction about the program will also obtained by pre- and post-test questionnaire (Appendix 14).

All information will be evaluated in monthly working committee meetings. Possible solutions and suggestions will be reviewed in the meeting in order to
achieve a more comprehensive plan for actual implementation. The proposed
guideline will be refined and submitted to the administrative level for final
endorsement by the end of 5th month.

4.3 Evaluation Plan

4.3.1 Nature and Number of Subjects

The eligible population consists of patients who will be scheduled for
elective open colorectal surgery under general anaesthesia. Any patients
undergoing laparoscopic or emergency surgery are excluded.

The sample size is calculated with reference to the primary outcome- the rate
of surgical site infection and it is obtained by Software named G-Power. The
current surgical site infection rate in the local setting is 7.7% (Poon et al., 2009).
An average 5% decrease in surgical site infection rate was detected from the four
selected studies (Greif et al., 2000; Belda et al. (2005; Mayzler et al., 2005;
Schietroma et al., 2012). Taking the expected decrease in surgical site infection be
5% after implementation of the proposed guideline, with power=80%, alpha=0.05,
constant proportion= 0.05, the sample size required is 169 patients after substitute
the data into the sample size calculator. Details on the sample size calculation are
shown in Appendix 17. Taking the dropout rate be 5%, the final sample size
required is 180 patients.
4.3.2 Outcomes measures

The primary outcome measure is the rate of surgical site infection. In the four selected randomized control trials (Greif et al., 2000; Belda et al., 2005; Mayzler et al., 2005; Schietroma et al., 2012), the rate of surgical site infection was used in all four studies as the primary outcome. Therefore, the guideline will be considered as effective only if the rate of surgical site infection found to be reduced, when compare to those who have not participated in this program and to the rate detected before the implementation of the program.

The secondary outcomes are identified and further divided into patient, healthcare provider and systems outcome.

Patient Outcomes: To describe the patient baseline characteristics in terms of patient characteristics and operative factors. The patient information including age, gender, education level and medical history will be recorded. Traditionally, patient factors such as age, diabetes, smoking, ASA score and obesity were commonly reported to be risk factors for surgical site infection (Mangram et al., 1999). On the other hand, the operative risks including operating time, operative blood loss and perioperative blood transfusion will be recorded. Based on a large population study, those operative risks were included in the risk index developed by the NNIS system for predicting the surgical site infection (Culver et al., 1991). Since
no such randomized control trial studies done in Hong Kong before, it is worthwhile to obtain the patients characteristics in the local hospital setting.

In addition, collect the data in relation to the surgical site infection rate. The criteria used for surgical site infection of the Infection Control Unit in local hospital are based on the definition of surgical site infection from the Centers for Disease Control and Prevention in the United States of America (Mangram et al., 1999).

Moreover, measure and compare the mean and total length of hospital stay, the number of re-admissions and mortality, if any. The patient satisfaction and acceptance of the new intervention will also be recorded.

Healthcare Provider Outcomes: Examination of healthcare provider outcomes involves process evaluation and allows one to evaluate how a project is operating. It can also help explaining the negative findings of the innovation and undesirable variations in care. The protocol implementation skills, teaching skills and compliance of nurses and anaesthetists on protocol utilization will be measured by their performance with the audit form (Appendix 16). Satisfaction level of staffs will also be assessed to evaluate the completeness of the briefing session (Fineout-Overholt & Johnston, 2007). It is measured by self-administrated questionnaire seen as attachment in Appendix 14.
System Outcomes: System outcomes are the facilities, supplies and organizational structure availability for the care provision. Cost related to the protocol implementation, nursing manpower requirement and utilization of feedback channels are the key parameters to be monitored.

4.3.3 Timing and Frequency of Taking Measurements

As different parameters will be collected from different stakeholders, the time and frequency of measurement are bound to vary. Patient outcomes are short-term measurements. They will be collected prospectively in a blinded fashion by the hospital audit team for each of the recruited case throughout the protocol implementation. Wound condition will be assessed by everyday ward round as usual and in out-patient clinic if discharged within 30-day postoperatively. Patients will be instructed to attend Accident and Emergency Department if there are any signs and symptoms of infection such as redness, swelling, increased temperature and pain around the wound site or fever before follow-up. A questionnaire will be given to patients during 30-day postoperative follow-up in out-patient clinic.

For healthcare provider outcomes, they require intermediate to long-term measurements. Training provision rehearsed on project coordinators will be evaluated for its adequacy immediately after train-the-trainer session in the second
month. However, evaluation of knowledge and views of general nurses with formal assessment will be conducted over a more extended period in the third, twelfth and twenty-fourth months, which is a before- and after-implementation design. Compliance with protocol will be evaluated for every recruited patient.

For system outcomes, they are generally intermediate measurements. They include monthly evaluation of nursing manpower and quarterly evaluation of the utilization and effectiveness of communication channels for gathering of staff opinions. Expenses directly contributed to the protocol implementation, such as stationeries, printing and publicity costs will be evaluated on monthly bases for the necessity of requesting additional resource. All measurements will be evaluated as a whole at the end of implementation of the program.

4.3.4 Analysis of Data

Data analysis of outcomes will be conducted by the analytical software named Statistical Package for Social Sciences.

For the primary outcome, in order to determine if the surgical site infection rate is changed since the implementation of the innovation, the local surgical site infection rate will be determined before the innovation. Also, significance testing using a two-tailed z-test for testing one proportion will be required. The characteristics of the participants, as well as the knowledge, compliance,
competence, and satisfaction level of the healthcare providers will be summarized using descriptive statistics. The 95% confidence intervals and a 5% level of significance will be used in all statistical tests.

For secondary outcomes, all subjects received the intervention from new innovation will be observed for the length of hospitalization, the number of re-admissions and mortality. The evaluation objective is to determine if the length of hospital stay, the number of re-admissions and mortality are changed since the implementation of the innovation. The data will be analyzed by two-tailed Z-test for one proportion with significance testing. The level of satisfaction of patients about the program is evaluated by a self-rating scale questionnaire as attached in Appendix 15. The questionnaire will be distributed and collected in the 30-day postoperative in out-patient clinic. The data will be analyzed by McNemar test.

For healthcare provider outcomes, the satisfaction and confidence level of all participated nurses are evaluated by a questionnaire as attached in Appendix 14. It is a self-administered questionnaire with a self-rating scale from 1 to 5, which need to be filled and sent back to the guideline proposer in a sealed envelope. The data will be analyzed by McNemar test. The level of knowledge and skills for administration of 80% oxygen for nurses and anaesthetists will be evaluated by observation and regular audit. The audit form is attached in Appendix 16. The
members of working committee are responsible for observing and monitor the
level of knowledge and skills for new proposed guideline.

For system outcomes, material cost, human resources and medical expenses
are calculated for evaluation. The manpower expenses are mainly the regular
meeting of working committee used for discusses and plans the innovation. Also,
the additional staff workload and the time spending for attend the briefing session.
The material cost includes print-out, the use of conference room and extra
expenses used on administration of 80% oxygen intra- and post-operation. The
medical expenses include the cost used in treating surgical site infection and the
extra cost of hospitalization.

For qualitative data such as reasons for non-compliance and comments from
staffs and patients require indexation into generate analytical categories, which
will be further refined and grouped to develop key theme. At the final stage,
explanations will be developed by clarifying connections between the range of
perceptions and experiences in relation to the identified themes.

4.3.5 Criteria for Determining Guideline Effectiveness

Guideline effectiveness is determined on the basis of the evidences adopted
for construction of the guideline. The proposed guideline is considered to be
effective if the following criteria are reached. The objectives are to achieve at least
5% reduction on surgical site infection rate, 3% reduction on mortality rate and 5% reduction in the length of hospitalization. In regards to healthcare provider outcomes, the objectives are to achieve 95% attendance in briefing session, 60% questionnaire response rate, 90% increase in knowledge for nurses and 60% increase in satisfaction level among nurses and anaesthetists. In terms of system outcomes, the aim is to pursue a status quo for feedback channel utilization rate and manpower resource. The final cost of this proposed guideline should not exceed HK$ 300,000, which is the estimated report in chapter 3 (Appendix 11). On the other hand, at least HK$160,000 per year should be saved after the implementation of proposed guideline in the local setting (Appendix 11).

The guideline will be reviewed and refined in regular basis according to the comments and feedbacks from stakeholders, and the evidence from updated literature reviews. The evaluation report of the implementation of the administration of 80% oxygen intra- and post-operation will be included in the formal report and distributed to the administrative team, including the Chief of Service of anaesthesia and Departmental Operation Manager, for final approval in actual clinical practices. The evaluation result will be distributed and the achievements the evidence based guideline development will be shared with all department staff during team meetings.
Figures and Tables
Figure 1
Flow diagram showing literature search results.

Search Term:
"Oxygen" AND
"Surgical site infection/wound infection/wound complication/postoperative complication" AND
"colon/rectum/colorectal surgery"

Electronic databases:
(1) Pubmed;
(2) 13 CINAHL plus (1974 to 2013);
(3) 173 Embase Classic and EMBASE(1974 to 2013);
(4) 97 The Cochrane library;
(5) 12 MEDLINE

384 potential relevant studies identified
(1) 53 Pubmed;
(2) 13 CINAHL plus (1974 to 2013);
(3) 173 Embase Classic and EMBASE(1974 to 2013);
(4) 97 The Cochrane library;
(5) 12 MEDLINE

1 study from manual searches by reviewing reference lists of the relevant studies

87 studies were retrieved for title and abstract screening

10 studies were excluded (Duplicated reports)

72 studies were excluded (not fulfilling the criteria)
• Non-colorectal-specified studies
• Laparoscopic or emergency surgeries
• Involving a bundle

4 randomized control trials studies were selected for literature review

298 were excluded (not RCTs)
Table 1
Pooled estimate on the Incidence of Surgical site infection of included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Odds Ratio</th>
<th>95% CI (CML)</th>
<th>% Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Fixed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Random)</td>
</tr>
<tr>
<td>Greif et al.,</td>
<td>13/250</td>
<td>28/250</td>
<td>0.435</td>
<td>0.202 to 0.895</td>
<td>39.110</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35.904</td>
</tr>
<tr>
<td>Belda et al.,</td>
<td>22/148</td>
<td>35/143</td>
<td>0.539</td>
<td>0.283 to 1.012</td>
<td>44.657</td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>47.767</td>
</tr>
<tr>
<td>Mayzler et al.,</td>
<td>2/19</td>
<td>3/19</td>
<td>0.627</td>
<td>0.047 to 6.322</td>
<td>3.955</td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.564</td>
</tr>
<tr>
<td>Schietroma et al.,</td>
<td>5/35</td>
<td>10/37</td>
<td>0.450</td>
<td>0.108 to 1.687</td>
<td>12.278</td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.765</td>
</tr>
<tr>
<td>Total</td>
<td>42/452</td>
<td>76/449</td>
<td>0.491</td>
<td>0.326 to 0.738</td>
<td></td>
</tr>
<tr>
<td>(Fixed effect)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>42/452 %</td>
<td>76/449</td>
<td>0.492</td>
<td>0.327 to 0.740</td>
<td></td>
</tr>
<tr>
<td>(Random effect)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Random effects (DerSimonian-Laird)
Chi² (test odds ratio differs from 1) = 11.555386  (df = 1) (P = 0.0007)

Table 2
Test for Heterogeneity on Surgical site infection.

<table>
<thead>
<tr>
<th>Cochran Q</th>
<th>0.299373</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF</td>
<td>3</td>
</tr>
<tr>
<td>Significance level</td>
<td>P = 0.9601</td>
</tr>
<tr>
<td>I² (inconsistency)</td>
<td>0%</td>
</tr>
<tr>
<td>95% CI</td>
<td>0% to 67.9%</td>
</tr>
</tbody>
</table>
**Figure 2**
Funnel plot to visually detect bias of included studies. Circles correspond to individual studies; and 0, no effect and equivalent to a risk ratio of 1.

**Figure 3**
Effect of supplemental oxygen on surgical site infection risk reduction in random effect. Squares represent individual RCTs lines attached to squares, individual 95% CI; diamonds, the combined effect of all included studies.
### Table 3
Pooled estimate on the Mortality.

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Control</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>% Weight (Fixed)</th>
<th>% Weight (Random)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greif et al., 2000</td>
<td>1/250</td>
<td>6/250</td>
<td>0.163</td>
<td>0.0035 to 1.3652</td>
<td>54.782</td>
<td>50.893</td>
</tr>
<tr>
<td>Belda et al., 2005</td>
<td>0/148</td>
<td>2/143</td>
<td>0.191</td>
<td>0 to 5.1384</td>
<td>23.230</td>
<td>24.769</td>
</tr>
<tr>
<td>Schietroma et al., 2012</td>
<td>0/35</td>
<td>2/37</td>
<td>0.200</td>
<td>0 to 5.6079</td>
<td>21.988</td>
<td>24.340</td>
</tr>
<tr>
<td>Total (Fixed effect)</td>
<td>1/433</td>
<td>10/430</td>
<td>0.178</td>
<td>0.0391 to 0.8082</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (Random effect)</td>
<td>1/433</td>
<td>10/430</td>
<td>0.178</td>
<td>0.0392 to 0.8114</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Random effects (DerSimonian-Laird)

Chi² (test odds ratio differs from 1) = 4.974237 (df = 1) (P = 0.0257)

### Table 4
Test for Heterogeneity on mortality.

<table>
<thead>
<tr>
<th>Cochrar Q</th>
<th>0.013777</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF</td>
<td>2</td>
</tr>
<tr>
<td>Significance level</td>
<td>P = 0.9931</td>
</tr>
<tr>
<td>F² (inconsistency)</td>
<td>0%</td>
</tr>
<tr>
<td>95% CI</td>
<td>0% to 72.9%</td>
</tr>
</tbody>
</table>
Figure 4
Effect of supplemental oxygen on mortality risk reduction in random effect.
Squares represent individual RCTs lines attached to squares, individual 95% CI; diamonds, the combined effect of all included studies.
Maylzer et al., 2005 did not mention the mortality rate.
<table>
<thead>
<tr>
<th>Bibliographic citation</th>
<th>Patient Characteristics</th>
<th>Intervention(s)</th>
<th>Comparison</th>
<th>Length of follow up</th>
<th>Outcome measures</th>
<th>Effect size (intervention – Comparison)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greif et al., 2000 Multicenter RCTs (++)*</td>
<td>elective open colorectal resection; ASA I and II and III*b</td>
<td>(n = 250) <strong>Intra-operation:</strong> 80% oxygen/20% nitrogen  <strong>Post-operation:</strong> 80% oxygen for 2 hours</td>
<td>(n = 250) <strong>Intra-operation:</strong> 30% oxygen/70% nitrogen  <strong>Post-operation:</strong> 30% oxygen for 2 hours</td>
<td>14 days after surgery</td>
<td><strong>Primary (%):</strong> 1)SSI 2)ASEPSIS score <strong>Secondary (Day):</strong> 3)First solid food intake 4)Length of hospital stay 5)Mortality (%)</td>
<td>1)-6 (P=.01) (RR*=0.464; P=.02) 2)-2 (P=.01) 3)+0.1 (P=.27) 4)+0.3 (P=.26) 5)-2</td>
</tr>
<tr>
<td>Belda et al., 2005 Multicenter RCTs (++)</td>
<td>elective open colorectal resection ASA I and II and III*b</td>
<td>(n = 148) <strong>Intra-operation:</strong> 80% oxygen/20% air  <strong>Post-operation</strong> 80% oxygen for 6 hours</td>
<td>(n = 143) <strong>Intra-operation:</strong> 30% oxygen/70% air  <strong>Post-operation</strong> 80% oxygen for 6 hours</td>
<td>14 days after surgery</td>
<td><strong>Primary (%):</strong> 1) SSI 2)Daily ASEPSIS score ≥20 at any time <strong>Secondary (day):</strong> 3)First solid food intake 4)Length of hospital stay 5)Mortality (%)</td>
<td>1)-9.5 (P=.04) (RR=0.607; P=.04) 2)-9 (P=.06) 3)-0.2 (P=.57) 4)+1.2 (P=.09) 5)-1.4</td>
</tr>
<tr>
<td>Bibliographic citation</td>
<td>Patient Characteristics</td>
<td>Intervention(s)</td>
<td>Comparison</td>
<td>Length of follow up</td>
<td>Outcome measures</td>
<td>Effect size (intervention – Comparison)</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------</td>
<td>-----------------</td>
<td>------------</td>
<td>--------------------</td>
<td>-----------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Mayzler et al., 2005 RCTs (+)</td>
<td>elective open colorectal surgery; ASA I and II;</td>
<td>(n=19) <strong>Intra-operation:</strong> 80% oxygen/20% nitrogen  <strong>Post-operation</strong> 80% oxygen for 2 hours</td>
<td>(n=19) <strong>Intra-operation:</strong> 30% oxygen/70% nitrous oxide  <strong>Post-operation</strong> 30% oxygen for 2 hours</td>
<td>30 days after surgery</td>
<td><strong>Primary:</strong> 1)SSI</td>
<td>1)-5.3 (P=.523) (RR=0.667; P=.64)</td>
</tr>
<tr>
<td>Schietroma et al., 2012 RCTs (+)</td>
<td>elective open colorectal resection; ASA I and II and III</td>
<td>(n=35) <strong>Intra-operation:</strong> 80% oxygen/20% nitrogen  <strong>Post-operation</strong> 80% oxygen for 6 hours</td>
<td>(n=37) <strong>Intra-operation:</strong> 30% oxygen/70% nitrogen  <strong>Post-operation</strong> 70% oxygen for 6 hours</td>
<td>Feb 2008-Feb 2011</td>
<td><strong>Primary (%):</strong> 1)SSI 2)Mortality</td>
<td>1) -12.8 (P&lt;.05) (0.526) 2) -5.4</td>
</tr>
</tbody>
</table>

*RR: Risk ratios
ª: ++: High quality; +: Acceptable; 0: Low quality
### Table 6
Quality assessment table of included RCTs (Internal Validity)

<table>
<thead>
<tr>
<th>Study</th>
<th>Clearly focused question</th>
<th>Random allocation</th>
<th>Adequate concealment</th>
<th>Double blind treatment allocation</th>
<th>Groups comparable</th>
<th>Only difference is treatment</th>
<th>Valid measurement of outcomes</th>
<th>Drop-out rate</th>
<th>Intent to treat analysis</th>
<th>Comparability results for multicenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grief et al. (2000)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>0%</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Belda et al. (2005)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Treatment:1.33%</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayzler et al. (2005)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>0%</td>
<td>✓</td>
<td>/</td>
</tr>
<tr>
<td>Schietroma et al. 2012</td>
<td>✓</td>
<td>✓</td>
<td>?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>0%</td>
<td>✓</td>
<td>/</td>
</tr>
</tbody>
</table>

Yes “✓”  No “✗”  Can’t say “?”  Does not apply “?”
Table 7  
Quality assessment table of included RCTs (Overall assessment)

<table>
<thead>
<tr>
<th>Study</th>
<th>Bias minimization</th>
<th>Effect due to intervention</th>
<th>Results applicable to target groups</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grief et al. (2000)</td>
<td>++</td>
<td>✓</td>
<td>✓</td>
<td>++</td>
</tr>
<tr>
<td>Belda et al. (2005)</td>
<td>++</td>
<td>✓</td>
<td>✓</td>
<td>++</td>
</tr>
<tr>
<td>Mayzler et al. (2005)</td>
<td>+</td>
<td>Small sample size, result may be underestimated</td>
<td>Further investigation may needed</td>
<td>+</td>
</tr>
<tr>
<td>Schietroma et al. 2012</td>
<td>+</td>
<td>Method of randomization and length of follow up did not disclose</td>
<td>✓</td>
<td>+</td>
</tr>
</tbody>
</table>

High quality (++): Acceptable (+): Unacceptable – reject (0): Yes “✓” No “✗”
Appendices
Appendix 1
Criteria for Defining a Surgical Site Infection (SSI)∗

**Superficial Incisional SSI**
Infection occurs within 30 days after the operation and
infection involves only skin or subcutaneous tissue of the incision and at least one of the following:
1. Purulent drainage, with or without laboratory confirmation, from the superficial incision.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision.
3. At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat and superficial incision is deliberately opened by surgeon, unless incision is culture-negative.
4. Diagnosis of superficial incisional SSI by the surgeon or attending physician.

Do not report the following conditions as SSI:
1. Stitch abscess (minimal inflammation and discharge confined to the points of suture penetration).
2. Infection of an episiotomy or newborn circumcision site.
3. Infected burn wound.
4. Incisional SSI that extends into the fascial and muscle layers (see deep incisional SSI).

*Note: Specific criteria are used for identifying infected episiotomy and circumcision sites and burn wounds.*

**Deep Incisional SSI**
Infection occurs within 30 days after the operation if no implant† is left in place or within 1 year if implant is in place and the infection appears to be related to the operation and
infection involves deep soft tissues (e.g., fascial and muscle layers) of the incision and at least one of the following:
1. Purulent drainage from the deep incision but not from the organ/space component of the surgical site.
2. A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38°C), localized pain, or tenderness, unless site is culture-negative.
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of a deep incisional SSI by a surgeon or attending physician.

*Notes:*
1. Report infection that involves both superficial and deep incision sites as deep incisional SSI.
2. Report an organ/pace SSI that drains through the incision as a deep incisional SSI.

**Organ/Space SSI**
Infection occurs within 30 days after the operation if no implant† is left in place or within 1 year if implant is in place and the infection appears to be related to the operation and
infection involves any part of the anatomy (e.g., organs or spaces), other than the incision, which was opened or manipulated during an operation and at least one of the following:
1. Purulent drainage from a drain that is placed through a stab wound‡ into the organ/pace.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/pace.
3. An abscess or other evidence of infection involving the organ/pace that is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of an organ/pace SSI by a surgeon or attending physician.

† National Nosocomial Infection Surveillance definition: a nonhuman-derived implantable foreign body (e.g., prosthetic heart valve, nonhuman vascular graft, mechanical heart, or hip prosthesis) that is permanently placed in a patient during surgery.
‡ If the area around a stab wound becomes infected, it is not an SSI. It is considered a skin or soft tissue infection, depending on its depth.

* Adopted from Mangram et al., (1999).
## Appendix 2
Methodology Checklist for RCTs by SIGN

<table>
<thead>
<tr>
<th>Study identification</th>
<th>(Include author, title, year of publication, journal title, pages)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guideline topic:</td>
<td>Key Question No: Reviewer:</td>
</tr>
</tbody>
</table>

**Before** completing this checklist, consider:

1. Is the paper a **randomised controlled trial** or a **controlled clinical trial**? If in doubt, check the study design algorithm available from SIGN and make sure you have the correct checklist. If it is a **controlled clinical trial** questions 1.2, 1.3, and 1.4 are not relevant, and the study cannot be rated higher than 1+

2. Is the paper relevant to key question? Analyse using PICO (Patient or Population Intervention Comparison Outcome). IF NO REJECT (give reason below). IF YES complete the checklist.

**Reason for rejection:** 1. Paper not relevant to key question £ 2. Other reason £ (please specify):

### SECTION 1: INTERNAL VALIDITY

**In a well conducted RCT study…**

<table>
<thead>
<tr>
<th>Does this study do it?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes £ Can’t say £ No £</td>
</tr>
</tbody>
</table>

1.1 The study addresses an appropriate and clearly focused question.  
1.2 The assignment of subjects to treatment groups is randomised.  
1.3 An adequate concealment method is used.  
1.4 Subjects and investigators are kept ‘blind’ about treatment allocation.  
1.5 The treatment and control groups are similar at the start of the trial.  
1.6 The only difference between groups is the treatment under investigation.  
1.7 All relevant outcomes are measured in a standard, valid and reliable way.  
1.8 What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed?  
1.9 All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis)  
1.10 Where the study is carried out at more than one site, results are comparable for all sites.

### SECTION 2: OVERALL ASSESSMENT OF THE STUDY

2.1 How well was the study done to minimise bias?  
**Code as follows**

High quality (++£)  
Acceptable (+£)  
Unacceptable – reject 0 £

2.2 Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, are you certain that the overall effect is due to the study intervention?  
2.3 Are the results of this study directly applicable to the patient group targeted by this guideline?  
2.4 **Notes.** Summarise the authors’ conclusions. Add any comments on your own assessment of the study, and the extent to which it answers your question and mention any areas of uncertainty raised above.
## Appendix 3
Comparison of demographic characteristics of patients and outcomes between local hospital and the four included studies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population considered (N)</td>
<td>715</td>
<td>500</td>
<td>291</td>
<td>38</td>
<td>72</td>
</tr>
<tr>
<td>Gender distribution ***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male§</td>
<td>404(56.5)</td>
<td>280(56)</td>
<td>162(55.7)</td>
<td>22(57.9)</td>
<td>40(56)</td>
</tr>
<tr>
<td>Female§</td>
<td>311(43.5)</td>
<td>220(44)</td>
<td>129(44.3)</td>
<td>16(42.1)</td>
<td>32(44)</td>
</tr>
<tr>
<td>Age (Year, mean) ¶</td>
<td>68</td>
<td>57±15</td>
<td>62.3±12.5/64.2±11.8</td>
<td>69±9/67±10</td>
<td>68.5(51-80)/70.3(54-83)</td>
</tr>
<tr>
<td>ASA class 3 and 4§</td>
<td>164(22.9)</td>
<td>18(7.2)/15(6)</td>
<td>33(23)/44(29.7)</td>
<td>Excluded</td>
<td>21(57)/20(57)</td>
</tr>
<tr>
<td>Perioperative blood transfusion§</td>
<td>59(8.2)</td>
<td>71(28)/78(31)</td>
<td>19(13.3)/23(15.5)</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Operating time#</td>
<td>146</td>
<td>186±234/180±126</td>
<td>--</td>
<td>135±40/140±40</td>
<td>190(105-360)/195(95-320)</td>
</tr>
<tr>
<td>SSI rate§</td>
<td>55(7.7)</td>
<td>28(11.2)/13(5.2)</td>
<td>35(24.4)/22(14.9)</td>
<td>3(15.8)/2(10.5)</td>
<td>10(27)/5(14.2)</td>
</tr>
<tr>
<td>Mortality§</td>
<td>11(1.1)</td>
<td>6(2.4)/1(0.4)</td>
<td>2(1.4)/0</td>
<td>--</td>
<td>2(5.4)/0</td>
</tr>
<tr>
<td>Hospitalization stay (Day, mean) ¶</td>
<td>Incisional:13</td>
<td>18.7±8.3/11.4±4.1</td>
<td>15.1±8.2/10.7±4.8</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Space/Organ:26</td>
<td>Mean: 19.5¶¶</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Data extracted from Poon et al. (2009).
** Data are presented as control versus intervention group reported in the studies.
*** Calculated percentages are rounded up to the closest figure.
¶ Figures are expressed as mean ± SD or mean (range) as reported in the studies.
¶¶ Figures are expressed as median as reported in the studies.
# Standardized as number of minutes for ease of cross-studies comparison and is expressed as mean (range) or mean ±SD as provided in some study.
§Date is presented as No. (%) unless otherwise specified.
### Appendix 4
ASA Physical Status Classification System

<table>
<thead>
<tr>
<th>ASA Physical Status 1</th>
<th>A normal healthy patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA Physical Status 2</td>
<td>A patient with mild systemic disease</td>
</tr>
<tr>
<td>ASA Physical Status 3</td>
<td>A patient with severe systemic disease</td>
</tr>
<tr>
<td>ASA Physical Status 4</td>
<td>A patient with severe systemic disease that is a constant threat to life</td>
</tr>
<tr>
<td>ASA Physical Status 5</td>
<td>A moribund patient who is not expected to survive without the operation</td>
</tr>
<tr>
<td>ASA Physical Status 6</td>
<td>A declared brain-dead patient whose organs are being removed for donor purposes</td>
</tr>
</tbody>
</table>

These definitions appear in each annual edition of the ASA Relative Value Guide®. There is no additional information that will help you further define these categories.

The ASA physical status classification system is adopted from ASA. ASA Physical Status Classification System. [cited 2014 Jan 8]; Available from: [http://www.asahq.org/Home/For-Members/Clinical-Information/ASA-Physical-Status-Classification-System](http://www.asahq.org/Home/For-Members/Clinical-Information/ASA-Physical-Status-Classification-System)
### Appendix 5
Annual Budget Estimation of Material Costs for current practice in 170 patients

<table>
<thead>
<tr>
<th>Materials</th>
<th>Unit Price (HK$)</th>
<th>Estimated unit</th>
<th>Estimated cost (HK$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen Cannula</td>
<td>$1.45</td>
<td>170 clients</td>
<td>$246.5</td>
</tr>
</tbody>
</table>

Total Estimated Cost (HK$) $246.5
Average Cost/patient (HK$) $1.45

### Appendix 6
Annual Estimated extra cost of hospitalization in 170 patients for proposed innovation

<table>
<thead>
<tr>
<th>Materials</th>
<th>Unit Price (HK$)</th>
<th>Estimated unit</th>
<th>Estimated cost (HK$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-rebreathing mask</td>
<td>$4.1</td>
<td>170 clients</td>
<td>$697</td>
</tr>
<tr>
<td>Photocopy fee for Educational leaflets and Evaluation forms</td>
<td>$0.2/page</td>
<td>170 Leaflets 170 Evaluation forms</td>
<td>$68</td>
</tr>
</tbody>
</table>

Total Estimated Cost (HK$) $765
Average Cost/patient (HK$) $4.5
Appendix 7
Estimated manpower/hour for the proposed innovation in a year in local hospital

<table>
<thead>
<tr>
<th>Items</th>
<th>Item description</th>
<th>Time Spent per item (Hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Theatre (n=80) Ward (n=4) Total annual client involved (n=170)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff relief from duty for training</td>
<td>1.5 hour/nurse</td>
<td>126</td>
</tr>
<tr>
<td>Extra preoperative explanation time</td>
<td>0.5 hour/patient</td>
<td>85</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>211</strong></td>
</tr>
<tr>
<td>Project supervisor (n=1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work meeting</td>
<td>2 hour/meeting 10 meetings in total</td>
<td>20</td>
</tr>
<tr>
<td>Staff training</td>
<td>1.5 hour/session 2 sessions in total</td>
<td>3</td>
</tr>
<tr>
<td>Monitoring</td>
<td>1 hour/ coordinators/week</td>
<td>48</td>
</tr>
<tr>
<td>Date analysis and report</td>
<td>6 bi-month report and 1 final report</td>
<td>56</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>127</strong></td>
</tr>
<tr>
<td>Project coordinators (n=2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work meeting</td>
<td>2 hour/meeting 10 meetings in total</td>
<td>40</td>
</tr>
<tr>
<td>Staff training</td>
<td>1.5 hour/session 2 sessions in total</td>
<td>6</td>
</tr>
<tr>
<td>Monitoring</td>
<td>1 hour/ coordinators/week</td>
<td>96</td>
</tr>
<tr>
<td>Date entry</td>
<td>0.5 hour/patient</td>
<td>85</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>227</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>565</strong></td>
</tr>
</tbody>
</table>
Appendix 8
Estimated personnel cost of the proposed innovation in a year

<table>
<thead>
<tr>
<th>Items</th>
<th>Time spent</th>
<th>Hourly cost (HK$)</th>
<th>Estimated Cost (HK$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff cost: project supervisor*¶</td>
<td>127</td>
<td>$281/hour</td>
<td>35,687</td>
</tr>
<tr>
<td>Staff cost: project coordinators*^</td>
<td>227</td>
<td>$177/hour</td>
<td>40179</td>
</tr>
<tr>
<td>Staff training^</td>
<td>126</td>
<td>$177/hour</td>
<td>22,302</td>
</tr>
<tr>
<td>Staff cost: ward^</td>
<td>85</td>
<td>$177/hour</td>
<td>15045</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>113,213</strong></td>
</tr>
</tbody>
</table>

*One Advanced Practice Nursing (APN) will act as project supervisor and two Registered nurses (RN) will act as project coordinators.

¶Hourly staff cost is calculated on the basis of mean salary of APN in local hospital as at January 2014 (The Hong Kong Hospital Authority Accounting Circular No. 15/2013

^Hourly staff cost is calculated on the basis of mean salary of RN in local hospital as at January 2014 (The Hong Kong Hospital Authority Accounting Circular No. 15/2013
### Appendix 9

Annual Estimated Current extra cost of hospitalization in 170 patients

<table>
<thead>
<tr>
<th>Items</th>
<th>SSI rate (%)^</th>
<th>Length of Stay (LOS) (days)^</th>
<th>Median LOS (days)^</th>
<th>Extra LOS (days)^</th>
<th>Extra Cost per SSI (HK$)*</th>
<th>Estimated patients who have SSI (n=170 x SSI %)</th>
<th>Estimated total extra cost (HK$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incisional SSI (median, day)</td>
<td>5.2</td>
<td>13</td>
<td>8</td>
<td>5</td>
<td>28,939</td>
<td>9</td>
<td>260451</td>
</tr>
<tr>
<td>Organ/Space (median, day)</td>
<td>2</td>
<td>26</td>
<td>8</td>
<td>18</td>
<td>42,917</td>
<td>4</td>
<td>171668</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>432119</td>
</tr>
</tbody>
</table>

*The data “Extra cost per SSI” was taking reference from a research paper in UK (Coello et al., 2005); price is converted into HK$ in a ratio of £1: HK$12.7652.

^Data extracted from Poon et al. (2009).
## Appendix 10

### Annual Budget Estimation of Material Costs for 170 patients for proposed Innovation

<table>
<thead>
<tr>
<th>Items</th>
<th>SSI rate (%)(^\wedge)</th>
<th>Length of Stay (LOS) (days)(^\wedge)</th>
<th>Median LOS (days)(^\wedge)</th>
<th>Extra LOS (days)(^\wedge)</th>
<th>Extra Cost per SSI per day <em>(HK$)</em></th>
<th>Estimated patients who have SSI (n=170 x SSI %)</th>
<th>Estimated total extra cost (HK$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incisional SSI (median, day)</td>
<td>5.2x4.35% =2.262</td>
<td>13</td>
<td>8</td>
<td>5</td>
<td>28,939</td>
<td>4</td>
<td>115756</td>
</tr>
<tr>
<td>Organ/Space (median, day)</td>
<td>2x4.35% =0.087</td>
<td>26</td>
<td>8</td>
<td>18</td>
<td>42,917</td>
<td>1</td>
<td>42917</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>158673</td>
</tr>
</tbody>
</table>

*The data “Extra cost per SSI” was taking reference from a research paper in UK (Coello et al., 2005); price is converted into HK$ in a ratio of £1: HK$12.7652.*

\(^\wedge\)Data extracted from Poon et al. (2009).
### Appendix 11

Estimated savings from the proposed innovation

<table>
<thead>
<tr>
<th>Items</th>
<th>Estimated Expense for 170 in current practice</th>
<th>Estimated Expense for 240 in proposed innovation</th>
<th>Net Balance in monetary terms (HK$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material cost</td>
<td>246.5</td>
<td>765</td>
<td>-518.5</td>
</tr>
<tr>
<td>Extra Personal Expenses</td>
<td>--</td>
<td>113213</td>
<td>-113213</td>
</tr>
<tr>
<td>Extra Cost of SSI</td>
<td>432119</td>
<td>158673</td>
<td>273446</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Total Savings</strong> 159714.5</td>
</tr>
</tbody>
</table>
Appendix 12
The evidence-based guideline

<table>
<thead>
<tr>
<th>An evidence-based protocol:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration of 80% oxygen concentration intraoperative and immediate postoperative for 2 hour to reduce surgical site infection in patients who undergo elective open colorectal surgery</td>
</tr>
</tbody>
</table>

1st Edition:
Next Revise:

I INTRODUCTION

1.1 Background
Surgical site infection (SSI) is the second most common health acquired infection (HAI). According to the Centers for Disease Control and Prevention, it accounts for 14% to 16% of all HAI. Applying strategies for the prevention of surgical site infection help to reduce surgical patients’ morbidity, mortality and length of stay, and save cost for the healthcare institutions.

A multidisciplinary team work approach is necessary to successfully implement the preventive measures and improvement in surgical site infection. Perioperative nurse play an important role in minimizing the incidence of surgical site infection by rigorous adherence to aseptic techniques and taking standard of care for patients undergoing surgical procedures. In recent year, extensive studies have investigated the effect of administration of 80% oxygen concentration over using 30% oxygen concentration intra- and postoperatively. (Gerif et al., 2000) In view of the significantly results obtained by the studies, there is a need to develop an evidence-based protocol of administration of 80% oxygen concentration intraoperative and immediate postoperative for 2 hour to reduce surgical site infection in patients who undergo elective open colorectal surgery.

1.2 Aim
The aim of the protocol is to summarize the available clinical evidences for the use of 80% oxygen concentration during the whole perioperative period on the patients undergoing colorectal surgery. The recommendations formatted serve as guideline clinical practice to enhance quality of care and reduces the incidence of surgical site infection in patients undergoing elective open colorectal surgery.

1.3 Who the protocol is for
This protocol is intended to support administration of supplemental oxygen during operating theatre. The personal involved include
• Nurses in operating theatre
• Surgeons
• Anesthesiologists
• Operation assistants

1.4 Target Population covered
Adult patients over 18 year-old undergo elective open colorectal surgery.

1.5 Population not covered
Patients undergo emergency or elective laparoscopic colorectal surgery and are not under the care of QMH OT.

II Methodology

2.1 Summary of Protocol development process
The method used to develop this Protocol are based on and modified from the framework recommended by the Scottish Intercollegiate Guidelines Network (SIGN). The stages used to develop this protocol were as follows:
• Determine the topic and develop scope of protocol
• Identify sources of evidence
• Retrieve potential evidence
• Evaluate potential evidence relating for eligibility, quality and relevance
• Extract relevant data from studies meeting clinical criteria
• Summarize and grade the body of evidence
• Formulate conclusions about the body of available evidence
• Formulate instructions and apply grading to the instructions
• Submit final draft to local experts for comments
• Amend instructions as indicated
• Submit final version to Operating Theatre Services for endorsement.

2.2 Search and Appraisal Strategies

2.2.1 Inclusion criteria
Studies design should be original studies in randomized control trials. Studies must focus on the adult patients (aged 18 or above) who undergo elective open colorectal surgery. Also, studies should be comparing supplemental oxygen intraoperative with standard oxygen concentrations with no administration of supplemental oxygen during and immediate after the procedure. Moreover, defined surgical site infection should be considered as...
2.2.2 Exclusion criteria

Studies focusing on non-colorectal-specified studies are excluded because colorectal patients are the main focus in this study. Also, studies on hyperbaric oxygen administration are also excluded, because the aim of the current dissertation is to investigate the hyperoxia or supplemental oxygen that could only be obtained at 1 atmosphere pressure. In addition, laparoscopic or emergency surgeries are excluded. Moreover, studies involving a bundle of interventions are excluded.

2.2.3 Electronic database choices

Five electronic databases are used. They are Pubmed, CINAHL plus (1974 to 2013), Embase Classic and EMBASE, The Cochrane library, and MEDLINE. There was no limitation on the period of the searching articles as well as on language used.

2.2.4 The use of keywords

The use of keywords divides into three categories which including infection, type of surgery and type of intervention. The keywords of infection included “wound infection”, “postoperative complication”, “wound complication” and “surgical site infection”. The keywords of the type of surgery were “colon”, “rectum” and “colorectal”. The keyword of the type of intervention was “oxygen”.

2.2.5 Screening process

The studies retrieved from the electronic databases were firstly screening on the bases of the inclusion and exclusion criteria for their eligibility to the titles and abstracts and then to the full-texts manually. In addition, reference lists of all relevant studies retrieved were manual searched.

2.2.6 Data Extraction

Dates were extracted in the form of tables of evidence, which helped to examine and categorize date. Characteristics of the studies and interventions are presented in the Tables.

2.2.7 Quality Assessment

Methodology checklists for randomized controlled trials developed by the
Scottish Intercollegiate Guidelines Network (SIGN) in May 2012 were used for quality assessment. The internal validity of the selected studies was evaluated according to the checklist. Levels of evidence were rated in accordance with the overall quality of the studies.

2.3 Search Results

A total of 384 relevant articles yielded from the electronic searches on August 2013. Limited to randomized controlled trials, 86 copies of relevant studies were retrieved. One study was produced by manual searches of reviewing reference lists of relevant studies. The titles and abstracts of those 87 copies of relevant studies were screened. Duplicated studies were eliminated and the studies were examined with reference to the inclusion and exclusion criteria. Only 4 studies were selected for evaluation after the abstract review.

2.4 Evidence synthesis and grading

Evidence grading was assigned to each evidence reviewed using the evidence hierarchy developed by the SIGN (Table 1).

For level of evidence, two studies (Greif et al., 2000; Belda et al., 2005) were rated as “I++” and two studies (Mayzler et al., 2005; Schietroma et al., 2012) were rated as “I+”.

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I++</td>
<td>High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias</td>
</tr>
<tr>
<td>I+</td>
<td>Well conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias</td>
</tr>
<tr>
<td>I</td>
<td>Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias</td>
</tr>
<tr>
<td>2++</td>
<td>High quality systematic reviews of case-control or cohort or studies</td>
</tr>
<tr>
<td></td>
<td>High quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal</td>
</tr>
<tr>
<td>2+</td>
<td>Well conducted case control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal</td>
</tr>
<tr>
<td>2</td>
<td>Case control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal</td>
</tr>
<tr>
<td>3</td>
<td>Non-analytic studies, e.g. case reports, case series</td>
</tr>
<tr>
<td>4</td>
<td>Expert opinion</td>
</tr>
</tbody>
</table>

*SIGN classification.*
2.5 Formulating and grading of instructions

For the formulation of instructions, the following factors were considered:

- Effectiveness data taking into account the strength of evidence and their effect size
- Reported data on additional outcomes such as cost data
- Feasibility of interventions
- Weighting of benefits against risks
- Transferability of the evidence to local setting regarding profiles of recruited patients

Grading of instructions was done using the recommendation-grading scheme developed by the SIGN (Table 2).

Table 2. Grades of recommendation

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>At least one meta-analysis, systematic review, or RCT rated as 1**, and directly applicable to the target population; or A systematic review of RCTs or a body of evidence consisting principally of studies rated as 1*, directly applicable to the target population, and demonstrating overall consistency of results</td>
</tr>
<tr>
<td>B</td>
<td>A body of evidence including studies rated as 2**, directly applicable to the target population, and demonstrating overall consistency of results; or Extrapolated evidence from studies rated as 1** or 1</td>
</tr>
<tr>
<td>C</td>
<td>A body of evidence including studies rated as 2*, directly applicable to the target population and demonstrating overall consistency of results; or Extrapolated evidence from studies rated as 2**</td>
</tr>
<tr>
<td>D</td>
<td>Evidence level 3 or 4; or Extrapolated evidence from studies rated as 2*</td>
</tr>
</tbody>
</table>

Note that this does not necessarily relate to the importance of the recommendation but to the predictive power of the supporting evidence.
### III Recommendations

<table>
<thead>
<tr>
<th>Recommendation 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients who undergo elective open colorectal surgery with ASA score I, II, and III only.</td>
</tr>
</tbody>
</table>

Grade of recommendation: A

Evidence: Togioka et al. (2012) [1++] concluded that patients underwent colorectal surgery showed a significant benefit of high concentration of oxygen administration in decreasing surgical site infection. Ward et al. (2008) [1+] found a well-established relationship exists between emergency procedures and the incidence of surgical site infection. It was investigated that patients with increase in American Society of Anesthesiologists (ASA) score showed an increase in the incidence of surgical site infection. (Tang et al., 2001) [1++]

<table>
<thead>
<tr>
<th>Recommendation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>80% oxygen concentration should be the first consideration for intra-operative.</td>
</tr>
</tbody>
</table>

Grade of recommendation: A

Evidence: Using high inspiration oxygen concentrations of 80% intra-operatively showed a significant reduce in the incidence of surgical site infection. (Greif et al., 2000[1++]; Belda et al., 2005[1++]; Mayzler et al., 2005[1+]; Schietroma et al., 2012[1+]).

<table>
<thead>
<tr>
<th>Recommendation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using a mixture of oxygen/air for the component of anesthesia carrier gas should be the first consideration. Otherwise a mixture of oxygen/ nitrogen is recommended in second choice.</td>
</tr>
</tbody>
</table>

Grade of recommendation: B

Evidence: Nitrous oxide played an important role in inhalational anesthesia in recent decades. It did not increase the incidence of surgical site infection (Fleischmann et al., 2005) [1-]. Fernandez-Guisasola et al. (2010) [1+] concluded that avoidance of nitrous oxide does reduce the risk of postoperative nausea and vomiting. Baum (2004) [2+] in a review pointed out that even using pure oxygen, the inspiratory oxygen concentration would not higher than
80-85%. And it was safe for healthy patients to use high inspiratory oxygen concentrations up to 6-8 hours. Baum (2004) [2+] concluded that medical air (nitrogen)/oxygen mixture seemed to be the most suitable substitute for nitrous oxide because of the universal property of the mixture of medical air and oxygen.

**Recommendation 4**

80% oxygen concentration should be administrated immediately after the surgery for 2 hours through a non-rebreathing mask.

Grade of recommendation: A

Evidence: In the study of Grief et al. (2000) [1++] provided supplemental oxygen for intra-operatively and for 2 postoperative hours. In contrast, both two studies (Belda et al. 2005 [1++]; Schietroma et al., 2012 [1+]) showed a nearly identical result by giving supplemental oxygen for 6 postoperative hours. All three studies (Grief et al., 2000 [1++]; Belda et al. 2005 [1++]; Schietroma et al., 2012 [1+] obtained a reduction of nearly half surgical site infection by using 80% oxygen concentration during the operation and for either 2 or 6 postoperative hours with significant p-value.

**Recommendation 5**

Ambient air should be recommended after 2 hours of 80% oxygen concentration administration to maintain a pulse oximetry at least 94%.

Grade of recommendation: A

Evidence: A previously research analysis a subgroup of 100 patients showed that using intraoperative FiO2 higher than 0.9 was not associated with increase oxygen requirement and suggested that it may be reasonable to use high inspired oxygen in surgical patients (Mackintosh et al., 2012) [1++]. Another subgroup analysis of 30 patients revealed that supplemental oxygen did not worsen pulmonary function or cause atelectasis as supported by using chest radiographs or computed tomographic scans (Akca et al., 1999) [1++]. Therefore, it is reasonable to allow ambient air after supplemental oxygen 2 postoperative hours if a pulse oximetry at least 94% is maintained.
Reference:


Appendix 13
Gantt chart for implementation of administration of 80% oxygen intra- and post-operative over a twelve-month period

<table>
<thead>
<tr>
<th>Task</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seek approval from managers &amp; COS</td>
<td>1</td>
</tr>
<tr>
<td>Gain support from and hold briefing session with nurses and anaesthetists</td>
<td>2</td>
</tr>
<tr>
<td>Marketing of the program</td>
<td>3</td>
</tr>
<tr>
<td>Pilot testing of the guideline and logistic logistics</td>
<td>4, 5</td>
</tr>
<tr>
<td>Amend guideline &amp; operational logistics as indicated</td>
<td>6</td>
</tr>
<tr>
<td>Implementation of the program</td>
<td>7, 8</td>
</tr>
<tr>
<td>Evaluation: system outcomes</td>
<td>9</td>
</tr>
<tr>
<td>Evaluation: healthcare provider outcomes</td>
<td>10</td>
</tr>
<tr>
<td>Evaluation: Patient outcomes</td>
<td>11</td>
</tr>
</tbody>
</table>

The chart indicates the timeline for each task, with completion marked by shading.
Appendix 14
Questionnaire for evaluating level of satisfaction from nurses

**Evaluation questionnaire for service providers**

Thank you for participating in the program. Please kindly take 1-2 minutes to fill out this evaluation questionnaire. Your comments and advice are highly valuable on determination of the quality provision of the program and aid in future improvements.

Please circle as appropriate:

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Training</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. You know the objectives of the program</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Content of intervention is easy to understand</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Instructions given are clear and comprehensible.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Adequate training is provided</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Overall, you are satisfied with the training provided.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>Service delivery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Interventions are easy to carry out.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. The time to carry out the intervention is adequate.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. Adequate resources and support given to carry out the intervention.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. The guideline improves the quality of patient care.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. Overall, you are satisfied with the mode of service delivery.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
**Usefulness**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>You know more about the effect of administration of high oxygen fraction after this program.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12.</td>
<td>You have acquired adequate skills in carrying out the guideline.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Feasibility**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.</td>
<td>You feel confident in conducting the guideline.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14.</td>
<td>You feel more stressful in carrying out the intervention.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15.</td>
<td>Your job satisfaction is increased by taking part in the guideline.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16.</td>
<td>The guideline is feasible to implement in the long term.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17.</td>
<td>Overall, this program is worth conducting.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Strengths of the program:

______________________________________________________________

______________________________________________________________

______________________________________________________________

Weakness of the program:

______________________________________________________________

______________________________________________________________

______________________________________________________________

Suggestions for improvement:

______________________________________________________________

______________________________________________________________

______________________________________________________________

The end
Thank you very much!
Appendix 15
Questionnaire for evaluating level of satisfaction from patients undergo elective open colorectal surgery

Evaluation questionnaire for participants
Thank you for participating in the program. Please kindly take 1-2 minutes to fill out this evaluation questionnaire. Your comments and advice are highly valuable on determination of the quality provision of the program and aid in future improvements.

Please circle as appropriate:

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Content of intervention is easy to understand.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Instructions given are clear and comprehensible.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Interventions are easy to carry out.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Nurses provide adequate assistance &amp; advice.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. The administration of 80% oxygen postoperative by 100% non-rebreathing mask for 2 hours is acceptable</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. You feel more confident in self-care after joining this program.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. You feel more stressful in taking part in this program.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. Overall, this program is worth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Strengths of the program:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Weakness of the program:

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

Suggestions for improvement:

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

The end
Thank you very much!
Appendix 16  
Audit Form for Administration of 80% Oxygen in Colorectal Patient

Please tick in the appropriate column.

<table>
<thead>
<tr>
<th>Patient in Operating Theatre</th>
<th>Standard Criteria</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Oxygen saturation is measured with pulse oximeters before and during anaesthesia, and throughout recovery.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 After the induction of anaesthesia and endotracheal intubation, patient receives 80% oxygen and 20% air till the end of the surgery.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Arterial blood is obtained one hour after the induction of anaesthesia and two hours after recovery from anaesthesia.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patient in Post Anaesthetic Care Unit</th>
<th>Standard Criteria</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Administer 80% oxygen through a non-rebreathing mask.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a Attach one end of oxygen tubing to mask and the other end to oxygen source. Adjust the flow to 15 liter/minute.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b Make sure the reservoir bag is inflated, then place mask over patient’s face, covering both nose and mouth.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c Slip elastic band over patient’s head and adjust for comfort and fit. For the best comfort, place straps below patient’s ears.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d Pinch nose clip to provide a seal around the nose.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Assure adequate and uninterrupted oxygen flow to patient. If oxygen flow is inadequate or interrupted, patient may not be able to inhale, or may not able to inhale adequate desired volume.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Allow patient to breathe ambient air after 2 hour postoperatively</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Additional oxygen is administrated if the oxygen saturation less than 94%.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Keep patient in PACU at least for 2 hours before discharge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 17
Sample size calculation

<table>
<thead>
<tr>
<th>RCT</th>
<th>Control, %</th>
<th>Intervention, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greif et al., 2000</td>
<td>11.2</td>
<td>5.2</td>
</tr>
<tr>
<td>Belda et al. (2005)</td>
<td>24.4</td>
<td>14.9</td>
</tr>
<tr>
<td>Mayzler et al., 2005</td>
<td>5.8</td>
<td>10.5</td>
</tr>
<tr>
<td>Schietroma et al., 2012</td>
<td>27</td>
<td>14.2</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>17.1</strong></td>
<td><strong>11.2</strong></td>
</tr>
</tbody>
</table>

Take the expected decrease in surgical site infection rate be 5%, with power=80%, alpha=0.05, after substitute the data into the sample size calculator, the sample size is 169 clients.

Taking the dropout rate be 5%, the final sample size required is 180 patients.
References


Belda, F. J., Aguilera, L., Garcia de la Asuncion, J., Alberti, J., Vicente, R.,
Ferrándiz, L., …Spanish Reduccion de la Tasa de Infeccion Quirurgica
wound infection: a randomized controlled trial. JAMA. 294(16), 2035–2042.

Bratzler, D.W., Houck, P. M., Richards, C., Steele, L., Dellinger, E. P., Fry, D.
baseline results from the National Surgical Infection Prevention Project.
Arch Surg. 140(2), 174-182.

348(7), 651–656.


Coelloa, R., Charlettb, A., Wilsona, J., Wardc, V., Pearsona, A. & Borriellod, P.
Journal of Hospital Infection. 60(2), 93–103.

class, operative procedure, and patient risk index. National Nosocomial


Anesthesiology. 91(5), 1246–1252.


Evidence-Based Nursing. 4(4), 210 - 219.


The Hong Kong Hospital Authority. (2013). Vision, Mission and Values. Retrieved from

98
The Hong Kong Hospital Authority. (2013). *Hospital Authority (HA) pay adjustment 2013. Hospital Authority Accounting Circular No. 15/2013*. Hong Kong: The Hong Kong Hospital Authority.


