EVALUATION OF NOSOCOMIAL INFECTION RATES IN DIABETIC PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFTING (CABG) SURGERY

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Evaluation of Nosocomial Infection Rates in Diabetic Patients Undergoing

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ABSTRACT

BACKGROUND: There is a conflict evidence about the association of using bilateral internal mammary artery (BIMA) grafting in diabetics undergoing coronary artery bypass grafting (CABG) surgery and increased risk of contracting surgical site infection. The direct impact of the diabetics glycemic control status and using the optimal grafting method on surgical site infection is still not conclusive in literature. The aim of the study is to evaluate the impact of Bilateral internal mammary artery grafting in diabetic patients, the diagnosis of diabetes mellitus, and its glycemic control status on different kinds of nosocomial infections. The assumption was made that those exposures associated with higher risk of surgical site infection, urinary tract infection, blood stream infection and pneumonia. **METHOD:** A retrospective cohort is conducted by utilizing Nationwide Inpatient Sample (NIS) data from the Agency of Healthcare Research and Quality (AHRQ). All patients who were admitted to coronary artery bypass grafting (CABG) surgery were retrieved from 2007 to 2012 and grouped based on the exposures of the study. **RESULTS:** The total sample of the study was 286,487 patients underwent CABG surgery. There were 122,642 (42.81%) patients diagnosed with Diabetes Mellitus, of whom 18,065 (14.73%) had uncontrolled hyperglycemia, 3,700 (3.01%) received Bilateral (IMA) and 103,577 (84.45%) unilateral or single (IMA) grafting method. The study population was predominantly white (79.78%) and male (72.08%) with an average age of 66 (SD ±10.89) old. About 215,740 (75.31%) of patients had developed nosocomial pneumonia, 16,667 (5.82%) urinary tract infections (UTIs), 9,442 (3.3%) sepsis or bloodstream infection (BSIs), and 5,302 (1.85%) surgical site infection (SSIs in overall sample population.

Among diabetic patients, there was no significant difference in comparing BIMA versus SIMA for surgical site infection (SSI) (p-value=0.2491) and blood stream infections (BSI) (p-value=0.6630). The results have also indicated that UTIs (4.2% vs. 5.5%; p-value=0.0005) was significantly lower with BIMA grafting method. However, results did not meet the hypothesis assumption regarding Pneumonias rate (76.8% vs. 70.5%; p-value < 0.0001) and was significantly higher with BIMA compared to SIMA grafting method. Multivariable analysis showed inconsistent result and confirmed that BIMA grafting predicts higher odd of BSI by 44.6% in diabetic, compared to SIMA grafting (OR: 1.446; 95% CI: 1.22-1.71; p<.0001).

The cross unadjusted baseline results for all nosocomial infections were significantly lower in diabetic patients compared to non-diabetic; Except for UTI was significantly higher by the presence of diabetes in BIMA grafting population (n=10,223) (4.2% vs. 3.39%; p-value= 0.0393). Multivariable analysis has confirmed that Diabetes Miletus increase the risk of UTI by 21.7% in BIMA population (OR: 1.217; 95% CI: 1.21-1.22; p<.0001).

The bivariate analysis results indicated that nosocomial infections were significantly higher in a diabetic with uncontrolled HbA1c compared to those with controlled diabetes. Except for nosocomial pneumonia. Adjusted results showed that uncontrolled hyperglycemia in a diabetic increase risk of UTI by 20% in overall and SIMA population. Uncontrolled hyperglycemia increase risk of SSI by 52% and UTI by 104% in diabetic undergoing BIMA grafting (SSI: OR 1.52; CI 1.50-1.53; p<.0001) (UTI: OR 2.049; CI 1.45-2.89; p<.0001).

CONCLUSION: In patients who underwent CABG surgery, Diabetes Mellitus (DM) was associated with significantly lower nosocomial infections. This may imply a better trend in nosocomial infections complications for diabetics compared to the total population of CABG. However, in diabetic patient's population, those stated with uncontrolled hyperglycemia have significantly higher risk of surgical site infection and urinary tract infection. Continuous insulin infusion protocol and intensive glycemic control monitoring are highly recommended for patients with uncontrolled diabetes during admission for CABG surgery. In diabetic patients who underwent CABG with Bilateral versus Single internal mammary (IMA), grafting, Bilateral IMA grafting was significantly associated with only higher odds of bloodstream infection in the diabetic patient and overall CABG population. BIMA grafting should be encouraged in diabetic patients. Expect in the case of uncontrolled hyperglycemia; it should be avoided due to the high risk of both SSI and UTI as it has been emphasized in other studies.

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CHAPTER 1

INTRODUCTION

Cardiovascular diseases (CVDs) — are number one leading cause of deaths in the world among all non-communicable diseases (NCDs). Each year, 17.5 million people die from CVDs, an estimated 48% of all NCD deaths and 31% of all cause of deaths worldwide (fig.1). Of these deaths, 7.4 million are due to coronary heart disease (CHD), and 6.7 million are due to stroke each year. Which makes Coronary Heart Disease (CHD) number one killer in the world. Governments are targeting to achieve more efforts on evidence-based policies for adoption of healthier lifestyles and access to primary healthcare. Which is to tackle the top leading risk factors for CVDs; hypertension, high cholesterol, obesity, diabetes, and smoking. In recent years, this has led to dramatic reduction in CVD deaths by 25% but, only in high-income developed countries. Middle and low-income courtiers are still having a high epidemic rate of CVD. Global effort on reducing the burden of diabetes mellitus and hypertension has been a very cost-effective and high-impact intervention in the reduction of cardiovascular diseases, especially Coronary Heart Disease. However, as the aging population is projected to increase in next two decades, annual CVD deaths will be projected to rise substantially from 17.5 million to 22.2 million in 2030. This increase will occur despite projected decreases in CVD death rates. There is a global target in which at least 50% of eligible patients around the world to have access to primary healthcare to receive drug therapy for diabetes and hypertension to control and prevent the increased incidence of heart attacks and strokes. **[1], [2]**

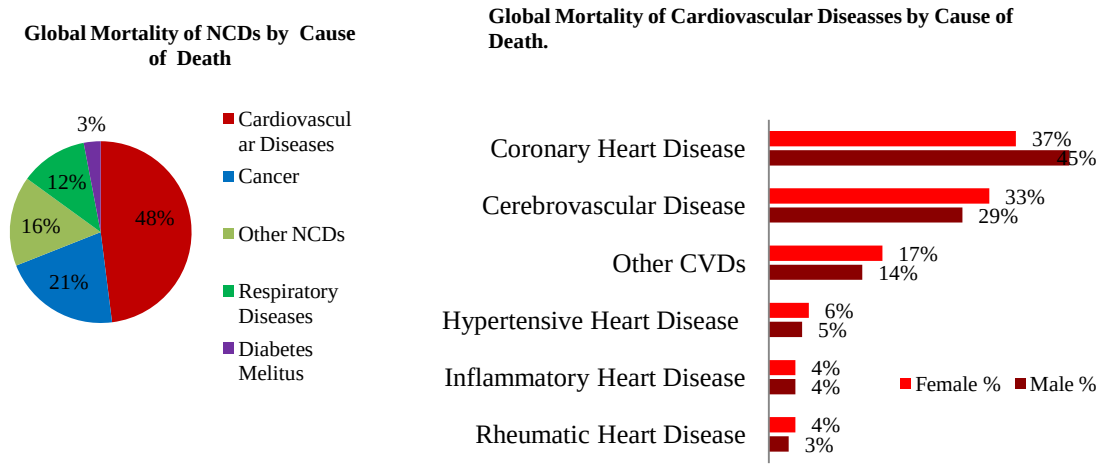


Figure 1: Global Mortality of Non-Commutable Chronic Diseases (NCDs) by cause of death. Source: WHO, 2011; Global Atlas on Cardiovascular Disease Prevention and Control, **[2]**

Diabetes is a well-recognized cause of death and disability (1.5 million deaths annually) in the United States. Diabetic patients who have no history of CVD are five times at risk of first heart attacks and strokes. Heart attacks can be prevented if high-risk individuals are detected and treated early. **[1,2]**

In the United States, Cardiovascular disease (CVD) account for 31% (786,641 deaths) of all NCDs (≈2.5 million deaths). Coronary heart disease (CHD) count nearly 50% of these deaths, killing 370,213 people alone each year. Currently, there are 85.6 million Americans affected by CVD, and 15.5 million of them are diagnosed with Coronary Heart Disease (CHD) at age 20 and above. Coronary artery disease (CHD) occurs more in older age population, and in men (7.6%) more than women (5%). The mortality rate is 50% higher in men compared to women per 100,000 in U.S. population (132.4 vs. 51.6), age-adjusted from 35-75 years old. The annual direct and indirect cost of heart disease is estimated $204.4 billion, $10.4 billion is for CHD and $11.5 billion for myocardial infarctions. **[3], [4], [5]**

According to last US census report, aging population is expected to increase in the United States from 46 to 74 million between 2014 and 2030. The aging population is projected to grow by 18 million in the next two decades. **[6]** With this expected growth in aging population, prevalence and medical cost of coronary heart disease (CHD) are projected to rise in next two decades from 2010 to 2030, according to AHA recent report statement. CHD incidence is going to increase by an additional 8 million from 15.5 to 23.5 million in 2030. Total direct and indirect costs of CHD will increase from $108.9 to $218.7 billion between 2010 and 2030. **[7]**

1.1 Background of the problem:

Coronary (or ischemic) Heart Disease (CHD) — is a cardiac condition that result from narrowed heart's blood vessels called coronary arteries by a pathological process known as *Atherosclerosis*. The atherosclerotic lesion, known as *Plaque*, cumulatively build up inside the coronary arteries and prevent normal blood flow to nourish the myocardium muscle with blood and oxygen. Failure of maintaining supply and demand of the heart muscle leads to *Myocardial Ischemia or Myocardial Infarction* (MI). This pathological process can start at a young age without symptoms for years till certain degree of obstruction that lead to manifest the disease signs and symptoms later in life. It manifests as a stable **chronic** condition, or it appears as **acute** unstable in nature. It depends on certain modifiable and non-modifiable risk factors. Diabetes mellitus is one of the independent modifiable risk factors for CHD. This is because both conditions share common pathological mechanism and leading risk factors, such as elevated low-density lipoprotein (LDL) and reduced high-density lipoprotein (HDL). Diabetes Mellitus

accelerate atherosclerotic lesion in CHD and its coexistence complicates outcomes of coronary revascularization treatment. Coronary Heart disease (CHD) is treated with drug therapy at first for stable conditions with less than %70 coronary artery occlusion. However, surgical intervention is required when medical therapy is insufficient to manage the complication of coronary heart disease with those who have more than %70 occlusion. Also is a must in emergency cases with plaque rupture or acute coronary syndrome. Surgeons operate on the vessel of the heart by many techniques under broad category called *Myocardial Perfusion or Coronary Revascularization* **[8], [9]**

Coronary Revascularization —is a set of procedures indicated to treat and retain normal blood flood to the ischemic area of the heart, which is affected by atherosclerosis. They are one of the most common performed surgeries in the United States. They fall into two broad type of categories: coronary artery bypass graft surgery (CABG) and catheter-based percutaneous coronary intervention (PCI). There are nearly 405,000 CABG and 954,000 PCI procedures performed annually in the United States, according to last NHDS report in 2010. **[10]** Coronary revascularization hospital discharges rate per 10,000 in population is 58.7 for PCI procedures and 9.9 for CABG procedures. The mean inflation-adjusted cost per hospitalization is $19,225 for PCI and $40,142 for CABG, according to the current NCHS report. The projection rate for coronary revascularizations is in decline from past years. [11]

Coronary Revascularization in Diabetics — There are nearly 1.5 million revascularization procedures, CABG and PCI, are performed annually in the United States. Approximately 25% of them are performed on diabetic patients. The prognosis is poor compared to non-diabetic patients **[12].** Diabetes is considering an important

prognostic factor for patients undergoing coronary revascularization. Because diabetic patients are host of unfavorable pathphysiological features of atherosclerosis. Diabetic patients with uncontrolled hyperglycemia show extensive macrovascular damage and contract accelerated the pathological process of atherosclerosis (plaque formation), which makes diabetes a risk factor for poor prognosis after coronary revascularization. Comparative studies of clinical trials showed evidence of CABG superiority over PCI procedure in diabetic patients with longer survival rate and fewer rate of repeated revascularizations. **[13]** Diabetic patients represent approximately 20% to 30% of patients undergoing CABG. Despite the recommendation of CABG procedure in diabetic patients, the effect of diabetes on a short-term outcome is unclear. One of these outcomes is a postoperative infection and other composites of outcomes are more associated with diabetics undergoing CABG. The adjusted risk for morbidity and mortality is higher in diabetics than non-diabetics by 35%, particularly among insulin-treated diabetics (adjusted risk between 1.5 to 1.61). **[14]**

1.2 Statement of the Problem:

CABG in Diabetics and Nosocomial Infections — Effectiveness of CABG on life expectancy in diabetics is well-documented. However, efficacy is directly related to the graft choice patency. According to a recent report from the American College of Cardiology Foundation/ American Heart Association (ACCF/AHA guidelines), adopting internal mammary artery in CABG surgery has a beneficial influence on morbidity and mortality. However, bilateral internal mammary artery (BIMA) grafting method was not

recommended in diabetic patients compared to single or unilateral internal mammary artery (SIMA) due to the higher risk of postoperative infections especially in diabetic patients when compared to a single internal mammary artery (SIMA) grafting **[15]**. Studies suggest that BIMA grafting anatomically contributes to low sternum blood flow, which leads to sternal ischemia and dehiscence (or mediastinitis). These complications result in higher risk of wound infection, compared to SIMA grafting **[73],[74].** However, according to retrospective studies by Lev-Ran, O. et al. **[58]** and Dorman, M. J. et al. **[60]** conclude that no significant difference in risk of deep sternal wound infection by BIMA relative to SIMA grafting. Experimental studies also favor CABG with internal mammary artery graft over other conservative procedures in diabetic patients for long-term survival[**16], [17**].

In the ACCF/AHA report, they concluded that there is a lack of consistent conclusion on the direct effect of diabetes clinical biomarkers and whether the degree of the glycemic control status (peri-operative uncontrolled hyperglycemia"HbA1c") in diabetic patients is considered as a predictor for short-term postoperative infection. They indicated a meta-analysis study of 409 clinical trials identified diabetes as an independent risk factor for major nosocomial adverse events in cardiac surgeries by 38% higher compared to non-diabetics. Suggesting that perioperative hyperglycemia in patients with diabetes is associated higher infection rates. However, they also indicated a randomized clinical trial from Mayo Clinic of 400 patients showed no difference in short-term outcomes between controlled vs. uncontrolled blood glucose perioperatively in ICU on the short-term outcome composites; death, infections, prolonged ventilation, cardiac

arrhythmia, postoperative stroke, and acute renal failure within 30 days of cardiac surgery The ACCF/AHA protocols have recommended an aggressive glycemic control therapy in diabetic patients with a tight peri-operative glucose treatment or continuous insulin infusion during CABG surgery for better control of infection rates, especially surgical site infections and dehiscence**. [15]**

Studies indicate that the effect of subpopulation disparity in diabetic patients is unclear on the postoperative outcomes and whether there are beneficial outcomes with respect to the intensive intra-operative glycemic control in diabetics. [**20], [21**] Some studies showed that intensive glycemic control during CABG was very effective in lowering the incidence rates of postoperative surgical site infection (SSI) and uncontrolled diabetes was an independent risk factor for postoperative infectious complications [**22], [23], [24**] However, the intra-operative intensive glycemic treatment significantly was linked to a high risk of hypoglycemic coma with no significant effect on the rates of postoperative infection in diabetic patients. [**25],[26**] Studies indicate that there is still limited evidence on the effect of perioperative uncontrolled hyperglycemia and treatment gap on the optimal therapy guidelines for uncontrolled diabetes in coronary revascularization.[**27],[28**].

Therefore, we aim to investigate whether BIMA grafting is a significant predictor of nosocomial infections in diabetic patients, compared to SIMA grafting? Also, to identify the short-term effect of diabetes and its glycemic control status on the rate of in-hospital nosocomial infections.

1.3 Objectives of the Study:

The increased rate of sternal wound infections has decreased the practice of bilateral internal mammary (or thoracic) (BIMA) grafting in diabetic patients. Despite the favorable benefit of BIMA grafting on the long-term survival of CABG patients and graft patency, compared to unilateral (or single) internal mammary artery (SIMA) grafting. Internal mammary artery (IMA) grafting is a routine practice in CABG surgeries. Therefore, one of the study goals is ;

- To examine the association and compare the effect of the bilateral internal mammary artery (BIMA) versus single internal mammary artery (SIMA) grafting method on nosocomial infections in diabetic patients.

Uncontrolled hyperglycemia has been linked to increased rate of nosocomial surgical site infection and bloodstream infections in hospitalized diabetic patients. It is common that diabetic patient who suffers long-term uncontrolled hyperglycemia are more susceptible to diabetic foot infection as a long-term complication. However, infection as an acute or short-term perioperative outcome is not clear for the diabetic patients undergoing surgery. As the diabetic patient population is increasing in CABG surgeries according to the latest American Heart Association (AHA) report. Protocol of intensive glycemic control by utilizing continuous insulin infusion during CABG surgery has been hypothesized to be effective in minimizing nosocomial infections rate in diabetic patients. Therefore, the study aim to the following;

- To evaluate the impact of diabetes Mellitus (DM) on the rate nosocomial infections in patients undergoing Coronary Artery Bypass Grafting (CABG).

- To examine the association and effect of the uncontrolled hyperglycemia status on the rate of perioperative nosocomial infections in diabetic patients. There is controversy in the literature about the perioperative glucose control status of diabetes during CABG surgery and the rate of nosocomial infections, particularity surgical site infection (sternal wound infection or mediastinitis).

1.4 Significance of the study:

The study will contribute to the bulk of knowledge needed in the pre-operative risk assessment of nosocomial infections in patients undergoing CABG surgery. Because of the rising admission rate of diabetic patients in CABG surgery suggests a need for rigorous research for these patients to inform a better decision on treatment choices, improve the informed-consent process, and control the rate of adverse events. Nosocomial infection is a problematic adverse event especially in immune-compromised patients like those with diabetes. The likelihood of infection after any operation depends mainly on the patients' immune system, and impairment of host immune defense is a major predisposing factor for perioperative infection. Therefore, evaluation of the preoperative risk factors improves identification of modifiable risks that are related to better outcomes after surgery such as patient's demographics, surgeons' skills, procedure-choice-related and hospital-process-related factors. The improvement of the prophylactic guidelines and frameworks during surgery is very crucial measures for prevention of nosocomial infections in immune-compromised patients undergoing CABG surgery. It contributes to a better healthcare delivery in such high-risk patients’ population.

The Centers for Disease Control and Prevention (CDC) has developed a National Nosocomial Infections Surveillance (NNIS) risk index for surgical infections. The most common surgical infections according to the NNIS are surgical site infections (SSI), pneumonia, urinary tract infection (UTI), bloodstream infections, and other Iatrogenic infections such as; catheter, graft vessel, or device-implants associated infections. The national rate of nosocomial infections is less common in coronary and cardiothoracic intensive care units than other types of units. However, it has a significant burden on complicating the operation outcomes and increasing the hospital recourses utilization. **[29], l30]** Also, studies have indicated that NNIS risk index performs less well for CABG than other types of surgery. There is a need for further research to better benchmark the risk of nosocomial infections in patients undergoing CABG surgery. **[31], [32]**

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction:

The review is designed based on a structural protocol (**ICVT**) described in Dunning J. et al. paper **[33].** The review process was divided into the following guided steps; formulating the review questions and clinical scenario, searching the database for the evidence, selecting the relevant studies, summarizing the best evidence studies, and concluding of the review. The review questions are represented with clinical scenario and formulated based on three elements or factors related to; patient, intervention, and outcomes. There is approach called "**PECODR**" published by Dawes, M. et al. **[34],** was incorporated in defining the review question and the searching strategy, to achieve more specific and sensitive search strategy**.** The PECODR method helps in formulating and searching well-structured review question in literature using MeSH database. Their method is based on well-known approach in evidence-based review (EBR) practice, which is called PICO (patient-intervention-comparison-outcome). It is used for structuring the clinical queries in literature databases. The PECODR method is re-defined it into six main elements; Patient/or Population (P), Interventions/or Exposure (I/E), Comparison/or control(C), Outcome (O), Duration (D), and Results (R).

2.2.1 Patients-Scenario and Review Questions*:*

Population (P) — A patient has a primary diagnosis of advance stage Coronary Heart Disease (CHD) and he is diagnosed with Diabetes Miletus (DM).

Exposure (E) — He is due to Coronary Artery bypass grafting (CABG) surgery. The

revascularization technique is open choice with either coronary artery bypass grafting (CABG-BIMA or CABG-SIMA grafting). His lab report indicated an uncontrolled diabetes or hyperglycemia (or elevated HbA1c level). He has history of diabetes complications or manifestations of acute and/or chronic hyperglycemia.

Outcomes(O) — What is the risk ratio of perioperative infectious complications in case of treating this patients? and ***(Control-C)*** — What is the difference in risk ratio of outcomes if patient is not risk-exposed? ***(Duration-D)*** — What is risk ration of outcome events in Short-term timeframe or during hospitalization? ***(Results-R)*** — Does the literature prove the association to be consistent and significant between exposure and outcome? Does the conclusion consider the exposure as predictor variable of outcomes?

<u>The Three-Parts Question:</u>

Among **[Patients with diabetes undergoing Coronary Artery Bypass Grafting (CABG) surgery],** Does **[Diabetes Millets (DM), Glycemic control status (hyperglycemia-HbA1c)** and/or specific **choice of revascularization method**] predict the risk of **[perioperative infections]?**

2.2.2 Database Search Strategy:

The Medline/ PubMed was searched by using the Medical Subject Subheadings (MeSH) database search builder. The suitable MeSH terms were identified and organized based on the PECODR elements of the review question (table 1). Terms about the **three-parts question** concepts [Population/Outcomes/Exposure] were added to the PubMed search builder to construct and run the search string. The MeSH terms were eliminated if performed poorly in search result. Different text words were adjusted and combined in

search string combinations to screen all possible related titles/abstracts. MeSH search qualifiers [exp, majr, mh] and LIMIT filters were used also to enhance the search specificity.

Table 1: Identification of MeSH terms list based on PECODR concepts

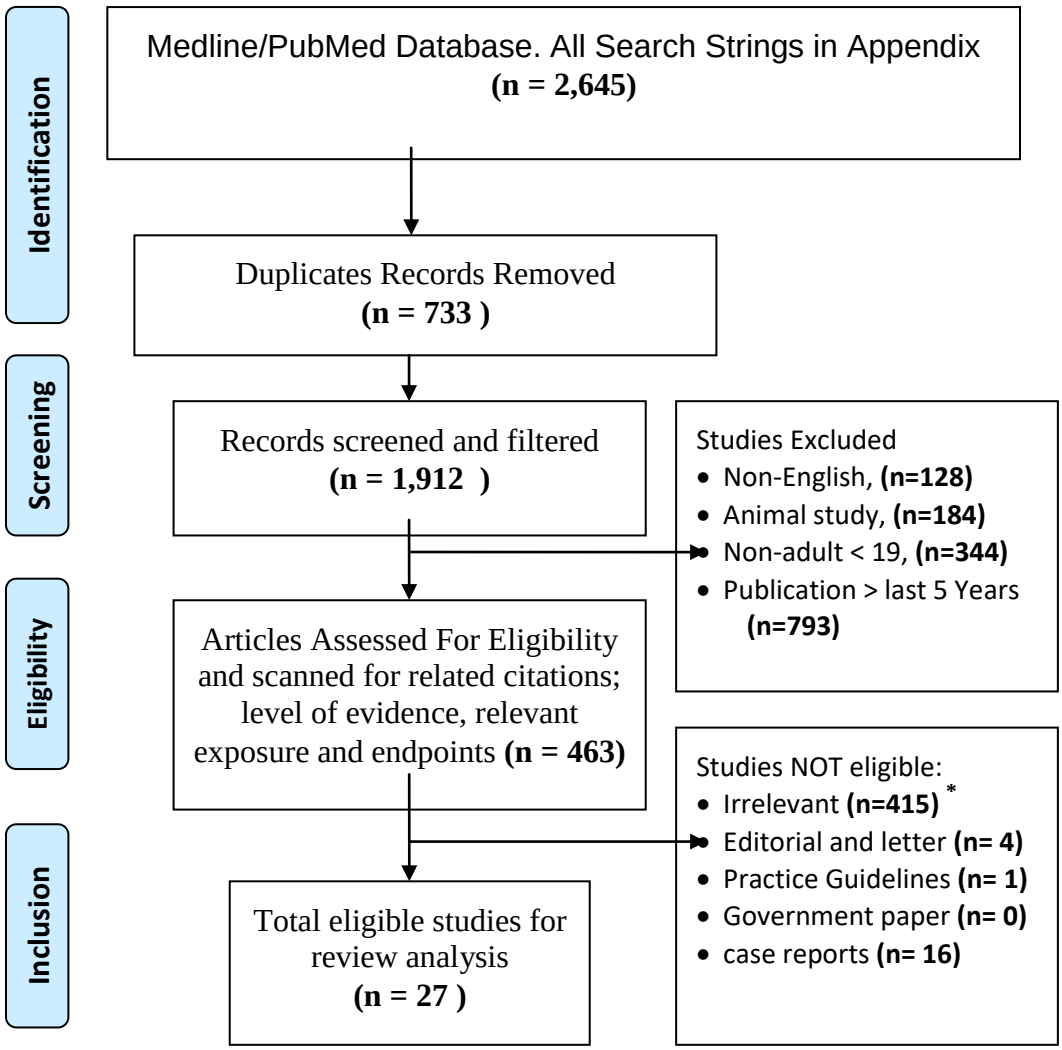
PECODR [a]	MeSH Keywords
Population	Coronary Heart Disease (CHD) and Coronary artery bypass grafting or CABG
Exposure	Diabetes Miletus (DM)or Hyperglycemias or Hemoglobin A, Glycosylated or Hb A1c or diabetes complications[text word] or Uncontrolled diabetes[text word].
Control	Case-control, retrospective studies
Outcomes	Cross infections, nosocomial infections, perioperative infections,
Duration	Time factors
Results	Statistics as topic, Meta-Analysis as Topic

[a] Dawes, M. Et al. [34]

2.2.3 Search Strings Results and Eligibility:

The search string, which was more systematic and specific to review question, was selected Studies were included and organized based on their level of evidence; systematic review and meta-analysis of randomized controlled trials, prospective and retrospective cohort studies. Studies were excluded if conducted on kids age, with irrelevant title/endpoints/exposure, or with small sample size and weak research design "gray literature" were excluded. (Fig. 2).

Figure 2: PRISMA Diagram



Source: Adopted From Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097. For more information, visit **www.prisma-statement.org**. **[35] * Studies with irrelevant title, targeted endpoints, and exposures were excluded.**

2.2 Review of Includded Studies:

2.2.1 Effect of Diabetes on nosocomial infections rate in CABG Surgery:

Zhang, X., et al. **[36]** conducted a meta-analysis of 132 studies to measure number of adverse outcomes in diabetic patients and non-diabetic patients after cardiac bypass surgery. Sternal wound infection was reported high in diabetic (DM) versus non-diabetic (NDM) patients; [2.29% (n=8,790) vs. 1.18% (n=23,261); risk ratio RR= 1.70 (1.14 - 2.04); p<0.00001]. Operative mortality at 30 days was also high DM vs. NDM; [3.25% (n=8,790) vs. 2.23% (n=23,261); risk ratio RR= 1.64 (1.39 - 1.93); p<0.00001].

Vranken, N. P., et al. **[37]** showed Diabetes mellitus is independent risk factor for post-cardiac surgery infections in 7888 patients undergoing cardiac surgery with median sternotomy and cardiopulmonary bypass. He reported 970 (12.3%) postoperative infections of which; surgical site infections (P = 0.001) and sepsis (P = 0.003) occurred more frequently in patients with diabetes mellitus.

Likosky, D. S., et al. **[38]** preformed retrospective review in 365,686 patients underwent isolated CABG. He studied Hospital-Level Infection Rates and the association factors; diabetes, smoking, chronic lung disease, and blood transfusion. Hospital infection events were; surgical site infections, deep sternal wound infection/or mediastinitis, harvesting-graft site infection, pneumonia, and sepsis. Diabetes is more prevalent in hospital with high infection rate with positive correlation; (p<0.001) with overall infections rate 3.97%, Pneumonia 2.98%, and sepsis 0.84%.

Raza, S., et al. **[39]** preformed retrospective cohort of 55,501 patients underwent

coronary artery bypass grafting surgery for the first time. Sample was grouped into 45,139 non-diabetics and 10,362 diabetics for comparison of outcomes. Groups were adjusted for bias by using Greedy matching or propensity score-matching for the preoperative risk factors. The analysis in diabetic versus non-diabetic showed that that outcomes significantly worse in diabetic patients in the prevalence of; in-hospital mortality (2.0% vs 1.3%) $p < 0.001$, deep sternal wound infections (2.3% vs. 1.2%); $p<0.001$ and septicemia (2.3% vs. 1.6%); $p=0.004$.

Saxena, A., et al. **[40]** reported that female patients with diabetes undergoing CABG surgery had a greater risk of 30-days mortality than men. In a cohort of 21, 534 patients underwent cardiac surgery CABG, female patients were presented more with diabetes mellitus ($P < 0.001$) and generally older (mean age, 68 vs. 65 years, $P < 0.001$) than men.

Lola, I., et al. **[41]** conducted a prospective study in 172 patients underwent cardiac surgery; of which were (n=59) diabetic. The objective was to study number of pre-, intra- and postoperative risk factors co-morbidities effect on nosocomial infections. Diabetes mellitus was identified as independent risk factor for postoperative infections (OR 5.92, CI 1.56 -22.42, $p = 0.009$). Out of 59 patients, 30 (17.42%) patients were infected; of which 13 (22%) had diabetes mellitus (DM). Overall endpoints were 8 (4.65%) with superficial wound infection, 5 (2.9%) with central venous catheter infections, 4 (2.32%) with pneumonia, 9 (5.23%) with sepsis, 1 (0.58%) with mediastinitis, 1 (0.58%) with harvest surgical site infection, 1 (0.58%) with urinary tract

infection, 1 (0.58%) with other major infection. Overall sample mortality was 3.48% and infection mortality rate was 25%.

Mannien, J., et al. **[42]** published a prospective study involving 4066 patients underwent different kind of cardiothoracic surgeries including: coronary artery bypass graft CABG procedures, valve surgery, and a combination of coronary artery bypass graft procedures with concomitant valve surgery. The preoperative effect of patient clinical profile was examined on the incidence of surgical site infections. A Follow up period of 42 postoperative days, 183 surgical site infections were reported; 2.4% for sternal wounds and 3.2% for harvest sites. Diabetes was important significant risk factor with 61% of SSIs.

Ledur, P., et al. **[43]** conducted a retrospective cohort of 717 patients underwent coronary artery bypass grafting surgery to study the effect of diabetes mellitus on the infectious complication after CABG. Diabetes was independent predictor for post-CABG infections (OR 4.18 [2.60-6.74], P<0.001). out of 717 patients; 29.6% had diabetes. 137 (19.1%) postoperative infections were reported of which; 62% respiratory, 25% superficial wound infections, 9.5% urinary tract infections UTI, and 3.6% deep wound infections.

2.2.2 Effect of Glycemic Control Status in Diabetic patients in CABG Surgery:

Tennyson, C., et al. **[44]** preformed systematic review of 11 studies were identified about hyperglycemia association to mortality and morbidity after cardiac surgery CABG, believed to provide best evidence. Out of 11 studies; 3 studies conclude

association of hyperglycemia (HbA1c) with significant increase in postoperative infections. Two identified a significant increase in infectious complications in patients with poorly controlled HbA1c, two of which were irrespective of previous diabetic status [deep sternal wound infection (P = 0.014); superficial sternal wound infection (P = 0.007) and minor infections (P = 0.006) in poorly controlled diabetics only].

Haga, K. K., et al. **[45]** conducted a meta-analysis of 9 Randomized controlled trials RCTs to study the effect of tight versus conventional glycemic control of the hyperglycemia in diabetic during cardiac surgery. In-hospital mortality or 30-days mortality was reported in three RCTs. First study was on 381 all non-diabetic with no significant difference (0% vs. 1.6%), second study was on 970 diabetic patients showed significant difference between tight and conventional glycemic control (37% vs. 16%); p=0.005, and third was on 141 diabetic patients with no significant difference in early mortality (0% vs. 0%). Meta-analysis results favor tight glycemic control to reduce in-hospital mortality; [OR 0.52, 95% CI (0.30 - 0.91)]

Subramaniam, B., et al. **[46]** conducted a prospective, observational cohort study in 1461 patients; 458 (31.3%) patients with HbA1c ≥ 6.5% and 1003 (68.7%) patients with HbA1c < 6.5%. The target was to measure the association of preoperative uncontrolled hyperglycemia HbA1c ≥ 6.5% and number of adverse events including; deep sternal wound infection and pneumonia. Deep sternal wound infections was significantly higher in group of uncontrolled hyperglycemia; [2.2% (n=458) vs. 0.5% (n=1003); Odd ratio OR= 1.64 (1.39 - 1.93); p=0.008]. There was no significant correlation between uncontrolled hyperglycemia and Pneumonia; p=0.177.

Burekovic, A., et al. **[47]** preformed retrospective study in 523 hospitalized patients in intensive care unit ICU. There were 450 diabetic patients; of which 204 (45.3%) developed postoperative acute infections. Hyperglycemia (HbA1c) is significantly higher in diabetic patients with postoperative infections, compared to diabetic without postoperative infections [11.9 (± 2.5) vs. 10.5 (± 2.3); 95% CI (2.08-0.69); p<0.001]. Urinary tract infection was the most prevalent than other infections; UTI (70%), Pneumonia (11.8%), soft tissue infections (10.3%), sepsis (6.9%).

Giakoumidakis, K., et al. **[48]** published a prospective study involving 212 patients underwent cardiac surgery CABG, valve surgery, and aorta aneurysm repair. The therapy group was 105 patients had insulin fusion to control blood glucose in range of 120-160 mg/dl. of which 27 (%25.7) had Diabetes. The control group was 107 patients underwent surgery with blood glucose level range from 161-200 mg/dl. of which 33 (%30.8) had Diabetics. Postoperative infection was not significantly different between control and therapy group; [12 (11.2) vs. 9 (8.6) p=0.519. Whereas, in-hospital mortality was significantly higher in control than therapy group; [7 (6.5) vs. 1(1.0); p=0.033].

Omar, A. S., et al. **[49]** conducted a prospective study in 227 patients underwent CABG and valve cardiac surgeries, comparing 100 diabetics versus 127 non-diabetic patients to examine the correlation of poor glycemic control and number of outcome complications. Of which, nosocomial infection was significantly higher in diabetic with poor in-range glycemic control (target in range TIR <80%), versus those with good in-range glycemic control TIR >80%; [13% (n=54) vs. 4.3% (n=46); p=0.09].

Ng, R. R., et al. **[50]** showed a results about the correlation of glycemic control risk factor in a retrospective cohort of 1442 patients underwent coronary artery bypass grafting. In two group grouped into HbA1c < 8 mmol/L (1019) and >8 mmol/L (423), Poor glucose control > 8 mmol/L was associated with increase surgical site infections (SSIs) [OR 3.131 (95% CI: 1.431 - 6.851), $P = 0.004$].

Greco, G., et al. **[51]** conducted a prospective cohort of 4,316 cardiac surgery patients. The sample stratified into; non-diabetic NDM (3,344), non-insulin treated diabetics NITDM (553), and insulin treated diabetics ITDM (419). Hyperglycemia (180 to 240 mg/dL) in non-diabetic patients was associated with increased risk of major postoperative infections by 1.6%, 95% CI (0.5 - 2.8); [0.040 (0.030 to 0.051) Vs. 0.019 (0.013 to 0.025)], compared to non-diabetic with no hyperglycemia (≤180 mg/dL). In insulin treated diabetics, hyperglycemia was associated with reduction in risk of postoperative infection by 4.1% -0.041 (-0.091 to 0.000) and no significant different in non-insulin dependent diabetic patients between Hyperglycemia and no hyperglycemia group. In-hospital mortality in NDM, NITDM, and ITDM was [29(0.9%), 5(0.9%), and 7 (1.7%)], respectively. ONLY in non-diabetics (NDM), poor glycemic control increases the risk of major postoperative infections after cardiac surgery. Among diabetics, insulin-treated diabetics (ITDM) with good controlled hyperglycemia in had worse rate of infections and mortality.

Rujirojindakul, P., et al. **[52]** published a randomized clinical trial in 200 participants (out of a planned assigned randomly into two groups; either intensive glucose control between 4.4 and 8.3 mmol/l group, ($n = 100$) or the conventional routine glucose

control more than 13.8 mmol/l group (*n* = 100). They found no significant difference in the risk of all infections [17% vs. 13%, p=0.43] and in-hospital mortality Intensive [6% vs. 8%, p=0.78] between intensive (4.4-8.3 mmol/L) vs. and control (≥13.8 mmol/L) groups.

Knapik, P., et al. **[53]** performed a retrospective cohort of 2665 patients underwent coronary artery bypass grafting surgery patients had diabetes mellitus. Of which were 735 (94.0%) diabetic patients, stratified into; 341 (46.4%) insulin-dependent, 290 (39.5%) oral anti-diabetic medication, and 104 (14.1%) diet controlled diabetes. The sample was matched using propensity score matching into two group based on level of blood glucose HbA1c >7%, n=170 group versus HbA1c ≤7%., n=170. Results showed that no significant difference between groups in incidence of postoperative outcomes; wound infections [0 vs. 3 (1.8%); 95% CI 1.98%, p=0.24], Sepsis [2 (1.2%) vs. 2(1.2%)], and death [2(1.2%) vs. 2(1.2%)].

Minakata, K., et al. **[54]** conducted a retrospective cohort of 1522 diabetes mellitus (DM) undergoing coronary artery bypass grafting (CABG). For comparison of outcomes, patients were divided into 849 diabetics and 572 non-diabetic patients. Postoperative infections rate was significantly higher in DM group than non-DM (9.2% vs. 6.1%, p=0.036) and all-cause mortality was higher in DM group also (2.1% vs. 1.1%, p=0.12)

2.2.3 Effect of BIMA Grafting Method Choice in Diabetic Patients in CABG Surgery:

Raza, S., et al. **[55]** conducted a retrospective study of 11,922 diabetic patients underwent coronary artery bypass grafting (CABG) surgery in Cleveland Clinic. The sample was stratified into 2743 insulin-treated and 3766 non-insulin-treated, and 1687 diet -controlled diabetics. One of main objective was to investigate the exposure to different revascularization techniques and their effect on postoperative complications including infections. There were 8466 (71%) patients underwent single internal thoracic artery (SITA) grafting, 938(7.9%) patients underwent bilateral internal thoracic artery (BITA) grafting, 2491(21%) patients had saphenous vein (SVG) grafting, 602 (5%) patients with off-pump versus on-pump CABG. Their results showed that BITA grafting was associated with a higher rate of deep sternal wound infections than SITA grafting; [OR 2.09, 68% CI (1.72-2.56), p =.0003]. Effect of off-pump versus on-pump showed no significant difference in infectious outcomes [OR (1.3 vs 2.2), p=.15].

Raja, S. G., et al. [**56]** preformed retrospective study on 1526 patients underwent coronary artery bypass grafting (CABG); 779 (51%) patients received radial artery (RA) grafting and 747 (49%) received single-right internal mammary (or called thoracic) artery (RIMA). The difference in incidence of deep sternal wound infection was not significant between RA versus RIMA groups [2.50% vs. 2.70%; p=0.8], respectively.

Kieser, T. M., et al. **[57]** conducted a retrospective analysis of a prospectively collected data on 1001 patients underwent coronary artery bypass grafting surgery; of which 345 (33%) diabetic patients. Out of 16 deep sternal wound infections cases, there were 14 patients underwent CABG with BITA grafts. Of the 14 patients, there were 9 diabetics.

Lev-Ran, O., et al. **[58]** has examined 147 diabetic patients underwent coronary artery bypass grafting (CABG). The main objective was to analyze the outcome of deep sternal wound infection after surgery. There were 83 patients with bilateral internal thoracic artery (BITA) graft and 64 patients with single radial artery (RA) graft. The adjusted analysis showed that BITA vs. RA groups have no significant difference (1.2% vs. 0%) in regards to the rate of deep sternal infection; [OR=2.24, 95% CL: (0.56-8.95), p=0.256]. The revascularization with BITA graft could not be identified as predictor for postoperative sternal wound infection in diabetic patients.

Ben Ahmed, H., et al. **[59]** retrospectively analyzed 228 patients underwent coronary artery bypass grafting (CABG). Of which, there were 126 diabetics and 102 non-diabetic patients underwent CABG with bilateral internal thoracic artery (BITA) graft. Comparing diabetic versus non-diabetic, in-hospital mortality was significantly higher in diabetic patients [(16% Vs 4.1%), P=0.005] and no significant difference in sternal wound infection in both diabetic and non-diabetic after CABG with BITA grafting.

Dorman, M. J., et al. **[60]** had retrospectively analyzed 1107 diabetic patients underwent coronary artery bypass grafting (CABG) surgery. Of which, 646 patients underwent CABG with single-internal mammary artery (SIMA) graft and 461 with bilateral-internal mammary artery graft. Sample was adjusted with propensity score matching and analyzed for operative mortality and sternal wound infection. Comparing SIMA [n=414] versus BIMA [n=414] groups; There were no significant difference in operative mortality [10 2.4% vs. 3.1%; P=0.279] and sternal wound infection [1.7% vs. 3.1%; P=0.179].

Deo, S. V., et al. **[61]** conducted a meta-analysis to compare the outcomes in CABG using either single or bilateral internal thoracic artery (SITA and BITA) in old patients. One of the primary endpoints are deep and superficial wound infections. A 9 studies have been identified that compared different endpoints between SITA and BITA. A pooled sample from 8 studies of 10,745 patients showed that BITA grafting method is associated with higher risk of deep sternal wound infection (DSWI) [Odd ratio 1.86 (1.35 - 2.57), p<0.0001] The funnel plot showed consistency in publication results (p=0.80). A 3 studies showed BITA is also associated with superficial sternal wound infection (SSWI) [OR 1.97 (1.23 - 3.15); p = 0.004].

Kajimoto, K. et al. **[62]** has done a meta-analysis of 13 retrospective studies to evaluate deep sternal wound infection in diabetic patients after CABG. A pooled analysis of 7,264 diabetic patients has showed that BITA grafting in diabetic patients is associated with increased risk of DSWI (relative risk 1.54; 95% CI (1.13-2.11), p=0.0069) with very low heterogeneity and no publication bias. However, overall estimate showed no significant difference between SITA and BITA in deep sternal wound infection with the use of skeletonization ITA harvest (RR 1.01; 95% CI (0.35 -2.97); p =0.98).

2.3 Summary Table of The Best Evidence:

Table 2: Summary of Best Evidence

Author/Year /level of evidence	Sample /Population (n)	Exposure/ and Endpoints	Study Results	Conclusion
Diabetes and Prevalence of Nosocomial infections				
1. Zhang, X., et al. (2011).	132 identified studies with total of 100,217 patient	Exposure; diabetes mellitus (DM)	diabetic versus non-diabetic In-hospital mortality at 30	Diabetic patients have increased risk of sternal

[36] Systematic review and met-analysis	underwent coronary artery bypass grafting CABG surgery - 28,168 with DM - 72,049 without DM	Outcomes; -Primary outcome: in-hospital mortality and -secondary outcomes: number of adverse events including sternal wound infection	days: pooled effect of 4 studies was [3.25% (n=8,790) vs. 2.23% (n=23,261); risk ratio RR= 1.64 (1.39 - 1.93); p<0.00001]. Sternal infections: pooled effect of 8 studies : [2.29% (n=8,790) vs. 1.18% (n=23,261); risk ratio RR= 1.70 (1.14 - 2.04); p<0.00001].	infection and mortality, compared non-diabetic
2. Vranken, N. P., et al. (2014). [37] Retrospective cohort	7888 patients undergoing cardiac surgery with median sternotomy and cardiopulmonary bypass.	Our interest just patient characteristics or profile development of post-cardiac surgery nosocomial infections.	970 (12.3%) postoperative infections. - surgical site infections (P = 0.001) and sepsis (p=0.003) occur more frequently In patients with diabetes mellitus	Diabetes mellitus is independent risk factor for post-cardiac surgery infections
3. Likosky, D. S., et al. (2015). [38] Retrospective study	- 365,686 patients underwent isolated CABG - Hospital-level Infection events and factors association; smoking, diabetes, chronic lung disease, and blood transfusion.	Exposure: Different perioperative factors composite including; Diabetes Outcomes: - surgical sit infects SSIs (deep sternal wound infection/ mediastinitis and harvesting-graft site infection)	Diabetes is more prevalent in hospital with high infection rate with positive correlation; (p<0.001) -3.97% overall infections rate - 2.98% Pneumonia - 0.84% sepsis	- Infection rates are varied among hospitals, but It increased in which had more patients with major co-morbidities. - Pneumonia and sepsis are more common infection

		- Pneumonia - Sepsis		
4. Raza, S., et al. (2015). [39] Retrospective Observational study	- Overall sample was 55,501 underwent first-time CABG grouped into; 10,361 diabetics (DM) patients and 45,139 non-diabetic patients By using propensity score matching (Greedy matching procedure), sample adjusted to; - 8926 diabetic patients - 8926 non-diabetic patients - history of follow up to 12 years	In-hospital Deaths Deep sternal wound infections	Diabetics vs. non-diabetic - In-hospital mortality (2.0% vs. 1.3%) p < 0.001 - deep sternal wound infections (2.3% vs. 1.2%); p<0.001 - Sepsis or septicemia (2.3% vs. 1.6%); p=0.004	Diabetes Miletus is a high risk factor for in-hospital mortality and postoperative sternal wound infection and septicemia. but, when adjusted with Greedy matching , only deep sternal wound infection was significantly different in diabetic versus non- diabetics (2.2% vs. 1.3%); p<0.001
5. Saxena, A., et al. (2012). [40] Retrospective Cohort study	21, 534 patients underwent cardiac surgery CABG	Exposure; impact of sex outcomes; compare the demographic, operative data and post-operative complications	Male vs. female 22.2% were female. - Female patients were generally older (mean age, 68 vs. 65 years, P < 0.001) and presented more often with diabetes mellitus (P < 0.001)	Female patients with diabetes undergoing isolated CABG surgery have a greater 30-day mortality

			- 30-day mortality (2.2% vs. 1.5%, P < 0.001)	
6. Lola, I., et al. (2011). [41] Prospective cohort study	172 patients underwent cardiac surgery; diabetic (n=59)	Exposure; Pre-, intra- and postoperative risk factors Only diabetes mellitus is our exposure of interest Outcomes; superficial sternal wound infection at the - central venous catheter infection- pneumonia- bacteremia, - mediastinitis - harvest surgical site infection- urinary tract infection,	diabetes mellitus identified as independent risk factor for postoperative infections (OR 5.92, CI 1.56 - 22.42, p = 0.009) total of 30 (17.42%) patients were infected; 13 (22%) with Diabetes mellitus (DM) 8 (4.65%) superficial wound infection 5 (2.9%) central venous catheter infection 4 (2.32%) pneumonia 9 (5.23%) bacteremia 1 (0.58%) mediastinitis 1 (0.58%) harvest surgical site infection 1 (0.58%) urinary tract infection, 1 (0.58%) other major infection. 25% infection mortality rate	Diabetes is a predisposing factor for postoperative infection. main limitations of the study is small sample size

			3.48% overall mortality	
7. Mannien, J., et al. (2011). [42] Retrospective cohort study	4066 cardiothoracic surgeries including: coronary artery bypass graft CABG procedures, valve surgery, and a combination of coronary artery bypass graft procedures with concomitant valve surgery Follow up period of 42 postoperative days.	Exposure; Patients' clinical profile Outcome; Surgical site infections SSIs	183 surgical site infections 2.4% for sternal wounds and 3.2% for harvest sites 61% of SSIs was reported after discharge	Diabetes was important significant risk factors,
8. Ledur, P., et al. (2011). [43] Retrospective cohort study	717 patients underwent coronary artery bypass grafting surgery	Exposure; demographic, diabetes, prolonged central venous line, and cardiac catheter Outcomes; Postoperative infections	- out of 717 patients; 29.6% had diabetes - 137 (19.1%) postoperative infections; - 62% respiratory, -25% superficial wound, -9.5% urinary, -3.6% deep wound Diabetes is predictor of postoperative infection (OR 4.18 [2.60-6.74], P<0.001)	Diabetes was predictor of post-CABG infections
The association between Glycemic control status and postoperative infection				

9. Tennyson, C., et al. (2013). [44] Systematic Review study	11 studies were identified about hyperglycemia association to mortality and morbidity after cardiac surgery CABG, believed to provide best evidence.	Exposure; hyperglycemia (HbA1c) in diabetics, non-diabetic, or mixed group Outcomes; all-cause or cause-related mortality and any morbidity. Endpoint of our interest are - postoperative infection All-cause mortality and infection-related mortality.	Out of 11 studies; 3 studies conclude association of hyperglycemia (HbA1c) with significant increase in postoperative infections two identified a significant increase in infectious complications in patients with poorly controlled HbA1c, two of which were irrespective of previous diabetic status [deep sternal wound infection (P = 0.014); superficial sternal wound infection (P = 0.007) and minor infections (P = 0.006) in poorly controlled diabetics only].	Only two studies have identified a significant increase in infectious complications in patients with poorly controlled HbA1c, two of which were irrespective of previous diabetic status [deep sternal wound infection (P = 0.014); superficial sternal wound infection (P = 0.007) and minor infections (P = 0.006) in poorly controlled diabetics.
10. Haga, K. K., et al. (2011). [45] Systematic review and meta-analysis	- meta-analysis of 9 Randomized controlled trials RCTs Of which - 3 RCTs yelled results on [the endpoint of our interest] early in-hospital mortality or 30-days mortality	Exposure: tight controlled vs. Uncontrolled of Glycaemia in diabetic patients during and after cardiac surgery Outcome; - In-hospital mortality; cited as "Early" 30-days mortality rate.	- pooled results of the 3 RCTs; Tight control vs. conventional control (normal and uncontrolled) - significant negative correlation between tight glycemic control and incidence of early mortality	The significant of controlling hyperglycemia during, before, and/or after cardiac surgery plays important role in reducing the incidence of early mortality.

	- 1st study 381 all non-diabetic - 2nd study 970 - 3rd study 141		[OR 0.52, 95% CI (0.30 - 0.91)]	
11. Subramaniam, B., et al. (2014). [46] prospective, single-center, observational cohort study	1461 patients undergoing coronary artery bypass grafting 458 (31.3%) patients with HbA1c ≥ 6.5% 1003 (68.7%) patients with HbA1c < 6.5%	Exposure; preoperative elevated hyperglycemia HbA1c ≥ 6.5% Outcomes; number of outcomes including the ones of our interest; - Deep sternal wound infections - Pneumonia - In-hospital mortality	HbA1c ≥ 6.5% vs. HbA1c < 6.5% - deep sternal wound infections was significantly higher in group of HbA1c ≥ 6.5%; [2.2% (n=458) vs. 0.5% (n=1003); Odd ratio OR= 1.64 (1.39 - 1.93); p=0.008]. - No significant difference in pneumonia; p=0.177 and in-hospital mortality or death; p=0.704	Preoperative Uncontrolled hyperglycemia is a significant predictor of major adverse events after CABG surgery; especially deep sternal wound infection
12. Burekovic, A., et al. (2014). [47] Retrospective cohort	523 hospitalized patients in intensive care unit ICU; of which 450 were diabetic.	Exposure: HbA1c level of control in intensive care unit (ICU), Outcomes: Prevalence of acute infections - Urinary tract infections (UTIs) - Pneumonia - skin and soft tissues infections - sepsis	204 infected; 35.3% men; 64.7 women; 61% age (61-80) - HbA1c) is significantly higher in diabetic patients with postoperative infections, compared to diabetic without postoperative infections [11.9 (± 2.5) vs. 10.5 (± 2.3); 95% CI (2.08-0.69); p<0.001]. - Urinary tract	Positive correlation between HbA1c level in patient with infection vs. without infection. -UTI was more frequent - infection is more in frequent in type 2 diabetes

			infection was the most prevalent than other infections; UTI (70%), Pneumonia (11.8%), soft tissue infections (10.3%), sepsis (6.9%).	
13. Giakoumidakis, K., et al. (2013). [48] Randomized Clinical trial (RCT)	- 212 patients underwent cardiac surgery CABG, valve surgery, and aorta aneurysm repair - 107 [Control group] patients underwent surgery with blood glucose level range from 161-200 mg/dl. of which 33 (%30.8) had Diabetics - 105 [Therapy group] patients had insulin fusion to control blood glucose in range of 120-160 mg/dl. of which 27 (%25.7) had Diabetes	Good vs. Poor glycemic control Effect on; - In-hospital mortality - Postoperative infections	Control (HbA1c 161-200 mg/dl) group vs. Therapy (HbA1c 120-160 mg/dl.) group; - In-hospital mortality; (%6.5 vs. %1.0), *p*=0.033 - postoperative infections; (%11.2 vs. %8.6), p=0.519	No significant difference in postoperative infections between control (HbA1c 161-200 mg/dl) and therapy group (HbA1c 120-160 mg/dl.). Only in-hospital mortality was considered statistically significant Glycemic control status was not statistically associated with postoperative infectious complications.
14. Omar, A. S., et al. (2015). [49] Prospective cohort study	sample size: - 227 patients CABG with cardiopulmonary bypass (CPB). - 100 non-diabetic - 127 diabetic;	- Exposure: Elevated glucose concentration more than 8% Outcomes; - In-hospital mortality	nosocomial infection was significantly higher in diabetic with poor in-range glycemic control (target in range	Diabetics with poor glycemic control have 3 times higher the risk of sternal wound infection compared to those with

	grouped into HbA1c > 8.1 mmol/L (>8%) and < 8.1 mmol/L (<8%) with time in range (TIR) being elevated HbA1c > 80% of the time of exposure	- incidence of wound infections	TIR <80%), versus those with good in-range glycemic control TIR >80%; [13% (n=54) vs. 4.3% (n=46); p=0.09].	Target in Range TIR <80% blood glucose during CABG surgery.
15. Ng, R. R., et al. (2015). [50] Retrospective cohort study	1442 diabetes patients only, Asian and undergoing elective CABG -grouped into HbA1c < 8 mmol/L (1019) and >8 mmol/L (423)	-Hyperglycemia > 8 mmol/L - incidence of surgical site infections (SSIs)	- Poor glucose control > 8 mmol/L associated with increase surgical site infection (SSIs) - OR 3.131 (95% CI: 1.431 - 6.851), *P* = 0.004	Good glycemic control < 8 mmol/L associated with a lower surgical site infection in diabetics undergoing elective CABG. Uncontrolled hyperglycmia increased risk of SSI by 213% in diabetics
16. Greco, G., et al. (2016). [51] Multicenter prospective cohort study	4,316 cardiac surgery patients Sample classified into; - 3,344 non-diabetics (NDM) - 553 non-insulin-treated diabetics (NITDM) - 419 insulin-treated diabetics (ITDM)	Exposure; Hyperglycemia (180 to 240 mg/dL) VS. No hyperglycemia ((≤180 mg/dL) Outcomes of our interest; - major postoperative infections - postoperative death.	(NDM); with hyperglycemia was associated with increased infections rate by 1.6%, 95% CI (0.5 -2.8) (ITDM); hyperglycemia associated with lower infection rate of -4.1% (-9.1 to 0.0) and no significant different in (NITDM) In-hospital mortality; NDM, NITDM, and ITDM; [29(0.9%), 5(0.9%), and 7 (1.7%)]	ONLY in non-diabetics (NDM), Poor glycemic control increases the risk of major postoperative infections after cardiac surgery. Among diabetics, good controlled hyperglycemia in insulin-treated diabetics had worse rate of infections and mortality.

17. Rujirojindakul, P., et al. (2014). [52] Prospective study (Randomized-double blinded)	- 200 patients underwent cardiac surgery-cardiopulmonary bypass. Had perioperative hyperglycemia irrespective to the diabetic history - Intensive glycaemic control (100 patients) to maintain glucose between 4.4-8.3 mmol/L [Intervention group] - conventional protocol glycemic control (100 patients) only maintain glucose to be ≥13.8 mmol/L [Control Group] Diabetic were randomized in both group.	Exposure: perioperative treated for hyperglycemia to maintain glucose (4.4 to 8.3 mmol/L) during hospitalization Outcomes; - Postoperative infections rate within 30 days. Include; - Surgical site infection SSI - Pneumonia - Urinary tract infection UTI - Sepsis	Intensive (8.3 mmol/L) vs. Conventional (13.8) control of glycemia Intensive vs. control - all Infections 17% vs. 13%, p=0.43, not significant - Deaths 6% vs. 8%, p=0.78, not significant	Glycemic control status in both diabetic and non-diabetic has no effect on the incidence of postoperative Infections Intensive insulin infuses increase risk of hypoglycemia by (23%) vs. (13%)
18. Knapik, P., et al. (2011). [53] Retrospective cohort	2665 patients, who underwent coronary revascularization 782 (29.3%) patients had diabetes mellitus of which; 341 (46.4%) insulin-dependent, 290 (39.5%) oral anti-diabetic medication, and 104 (14.1%) diet controlled diabetes.	Exposure; elevated HbA1c among diabetic patients scheduled for coronary surgery Outcomes; number of outcomes of which; -postoperative wound infections - Sepsis - Postoperative deaths	wound infections [0 vs. 3 (1.8%) ; 95% CI 1.98%, p=0.24], Sepsis [2 (1.2%) vs. 2(1.2%)], and death [2(1.2%) vs. 2(1.2%)].	No significant difference with respect to the control level of HBA1C among diabetics in postoperative wound infections, sepsis and death

	Grouped into; - Normal HbA1c (≤7%) - elevated HbA1c (>7%)			
19. Mina kata, K., et al. (2012). [54] Retrospective cohort study	1522 diabetes mellitus (DM) undergoing coronary artery bypass grafting (CABG) 849 DM vs. 572 non-DM patients	the impact of diabetes mellitus (DM) Outcomes; Postoperative infections All-cause mortality	DM vs. Non-DM - postoperative infection was significantly higher in DM group than non-DM (9.2% vs. 6.1%, p=0.036) - all-cause mortality was higher in DM group also (2.1% vs. 1.1%, p=0.12)	Diabetes Mellitus is statistically significant risk factor for postoperative infection and mortality
The association between choice of revascularization method and postoperative infection in *Diabetics*				
20. Raza, S., et al. (2014). [55] Retrospective cohort study	- 11,922 diabetic patients undergoing CABG - grouped into diabetic patients with bilateral internal thoracic artery grafting (BITA), n= 938; 7.9% - diabetic patient with single internal thoracic grafting (SITA) off-pump, n=602; 5% - SITA on-pump, n=2109; 18%	BITA vs. SITA grafting method in CABG Off pump vs. on-pump - Deep sternal wound infections (DSWIs) - infection-related mortality	BITA grafting diabetic has 73% increased risk of DSWIs - 80% for female - 7% for high BMI	BITA increase risk of DSWI by 73% and should be avoided in diabetic female with high BMI due to high risk of postoperative infection However, BITA grafting can improve long-term survival with complete revascularizatio n

21. Raja, S. G., et al. (2015). [56] Prospective cohort study	- 1,526 coronary artery bypass grafting surgeries CABG - 747 Patients underwent single- right internal mammary artery (RIMA) - 779 patients underwent radial artery RT grafting bypass - Randomized from 2001-2013	Exposure; diabetes with single -RIMA grafting in CABG Outcomes: deep sternal wound infection. - long-term mortality	- among patients, those with diabetes have increased events of deep sternal wound infections (p= 0.8) - RT grafting increase risk of late-mortality in diabetics [hazard ratio HR 3.3; 95% CI (1.1-9.7)] and obese [HR 2.1; 95% CI (0.8 - 5.46)]	Right-SIMA is strongly recommended as first choice in CABG grafting method.
21. Kiser, T. M., et al. (2014). [57] Retrospective cohort study	1001 patients underwent CABG, 345 (33%) diabetic. Study from 2003-2012 - 689 patients received BIMA or BITA graft, - 59 patients with SITA graft and other different grafting methods divided into two cohorts; - Before institution change in infection control precautions measures - After institution change in infection control	Exposure; Different precautions measure in two different point in time database. One of them is avoidance of BITA graft in obese diabetic patients Outcome; Deep sternal wound infection DSWI rate after CABG-BITA grafting method	before changing measures point group (532 patients); a 16 (3%) DSWIs in 28 obese diabetic women (BMI > 30) After changing point group; Avoidance of BITA in obese diabetic women	CABG with BITA grafting in obese diabetic patients, especially female gender is associated with increased risk of postoperative deep sternal wound infection

	precautions measures			
23. Lev-Ran, O., et al. (2013). [58] Prospective cohort study	147 insulin - dependent type-2-diabetic patients underwent CABG Of which: - 83 patient received bilateral internal thoracic artery BITA graft -64 received Radial artery graft	- BITA vs. RA grafts Outcomes: - Deep sternal wound infection DSWI - superficial wound infection - mortality	- BITA vs. RA grafts DSWI could not be identified as independent predictor (OR= 2.24, 95%CI: 0.56–8.95, p=0.256)	BITA grating is not consider be a predictor or risk factor for DSWI. It can be used in diabetic patients with no significant difference in risks ratio to other methods
24. Dorman, M. J., et al. (2012). [60] Retrospective cohort study	1107 consecutive diabetic patients underwent coronary artery bypass grafting IMA (n=646) or BIMA (n=461) grafting with the propensity score was used to create matched SIMA (n=414) and BIMA (n=414)	Exposure bilateral internal mammary artery (BIMA) grafting Vs. single internal mammary artery (SIMA) grafting Outcomes; operative mortality sternal wound infection long-term survival determined by follow-up (6 weeks to 30.1 years; mean, 8.9 years)	SIMA [n=414] Vs. BIMA [n=414] groups; - operative mortality, [10 2.4% vs. 3.1%; P=0.279] sternal wound infection, [1.7% vs. 3.1%; P=0.179] Survival, [9.8 vs. 13.1 years ; P=0.001]	Bilateral internal mammary artery grafting (BIMA) was associated with better long-term survival up to 8.9 years - with no significant difference in the incidence of sternal wound infection and in-hospital mortality.

2.4 Conclusion of The Literature Review:

Nosocomial infections were rarely reported after percutanous coronary intervention (PCI) in diabetic patients. Operative infections were commonly reported in coronary artery bypass grafting (CABG) procedure. Therefore, the study cohort will be on the

invasive revascularization technique CABG. Diabetes and obesity were prominent patient-related predisposing factors for nosocomial infection in patient undergoing cardiac surgery. The sternal wound infection was studied intensively in diabetic patients undergoing CABG surgery. Poor acute hyperglycaemic control was one of the reported predictor factor for nosocomial infection irrespective of the diabetes diagnosis. There were small number of studies have called into the predictive value of the glycemic control status in diabetic patients. The bilateral internal mammary artery (BIMA), which is a type of artery anastomosis conduct method of revascularization used in CABG surgery, was reported a high risk for postoperative wound infection and in-hospital mortality in diabetic patients. Reviews of clinical trials and meta-analysis studies indicated conflicted conclusions in regards to the casual inference of the relationship between the grafting method and the infectious outcomes in diabetic patient population. Therefore, hypotheses of this research will be relevant to these three exposures detected in literature review: diabetes status, poor acute hyperglycemic control status, and method of revascularization surgery.

2.5 Research Questions and Hypotheses:

A. **HYPOTHEIS (A.a):** Is there a significant difference in rate of nosocomial infections by the choosing the grafting technique; Bilateral Internal Mammary Artery (BIMA) compared to Single Internal Mammary Artery (SIMA) ?

   – **Null hypothesis: (H0 = H1):** SIMA and BIMA grafting methods have no significant difference in the rate of nosocomial infections in CABG patients.

- **Alternative hypothesis (H0 ≠ H1):** BIMA grafting has higher rates of nosocomial infections than SIMA grafting.

B. **SUB-HYPOTHESIS (A.b):** For diabetic patients ONLY, is there a significant difference in rate of nosocomial infections by choosing Bilateral Internal Mammary Artery (BIMA) compared to Single Internal Mammary Artery (SIMA)?

- **Null hypothesis (H0 = H1):** SIMA and BIMA grafting methods have no significant difference in the rate of nosocomial infections in Diabetic-CABG patients.
- **Alternative hypothesis (H0 ≠ H1):** BIMA grafting has higher rates of nosocomial infection than SIMA grafting in Diabetic-CABG patients.

C. **HYPOTHESIS (B):** Is there a significant difference in the cumulative incidence rate of nosocomial infections between diabetic and non-diabetic patients undergoing Coronary Artery Bypass Grafting (CABG) surgery?

- **Null hypothesis (H0 = H1):** Diabetic and Non-diabetic patients admitted to CABG surgery have no significant difference in rate of nosocomial infections (NIs)
- **Alternative hypothesis (H0 ≠ H1):** Diabetic patients have significantly higher rate of nosocomial infections than non-diabetic patients. **(in total CABG, BIMA only, SIMA only)**

D. **HYPOTHESIS (C):** Is there a significant difference in the cumulative incidence of nosocomial infections (NIs) between diabetics with uncontrolled hyperglycemia and controlled hyperglycemia in CABG surgery?

- **Null hypothesis (H0 = H1):** Diabetics with uncontrolled and controlled hyperglycemia have no significant difference in rate of nosocomial infections (NIs).
- **Alternative hypothesis (H0 ≠ H1):** Diabetic patients with poor hyperglycemic control undergoing CABG surgery have higher rate of nosocomial infections than patients with controlled diabetes **(in total CABG, BIMA only, SIMA only**

CHAPTER 3

METHODOLOGY

3.1 Objectives:

- Analyze the association and predictive value of Bilateral internal mammary artery grafting and the risk of nosocomial infections in diabetic patients undergoing coronary artery bypass grafting (CABG) surgery
- Analyze the association and predictive value of diabetes mellitus diagnosis on risk of nosocomial infections in patients undergoing coronary artery bypass grafting (CABG) surgery
- Analyze the impact of uncontrolled Hyperglycemia or poor hyperglycemic control on the rate of nosocomial infections in diabetic patients undergoing coronary artery bypass grafting (CABG) surgery.

3.2 Data Source:

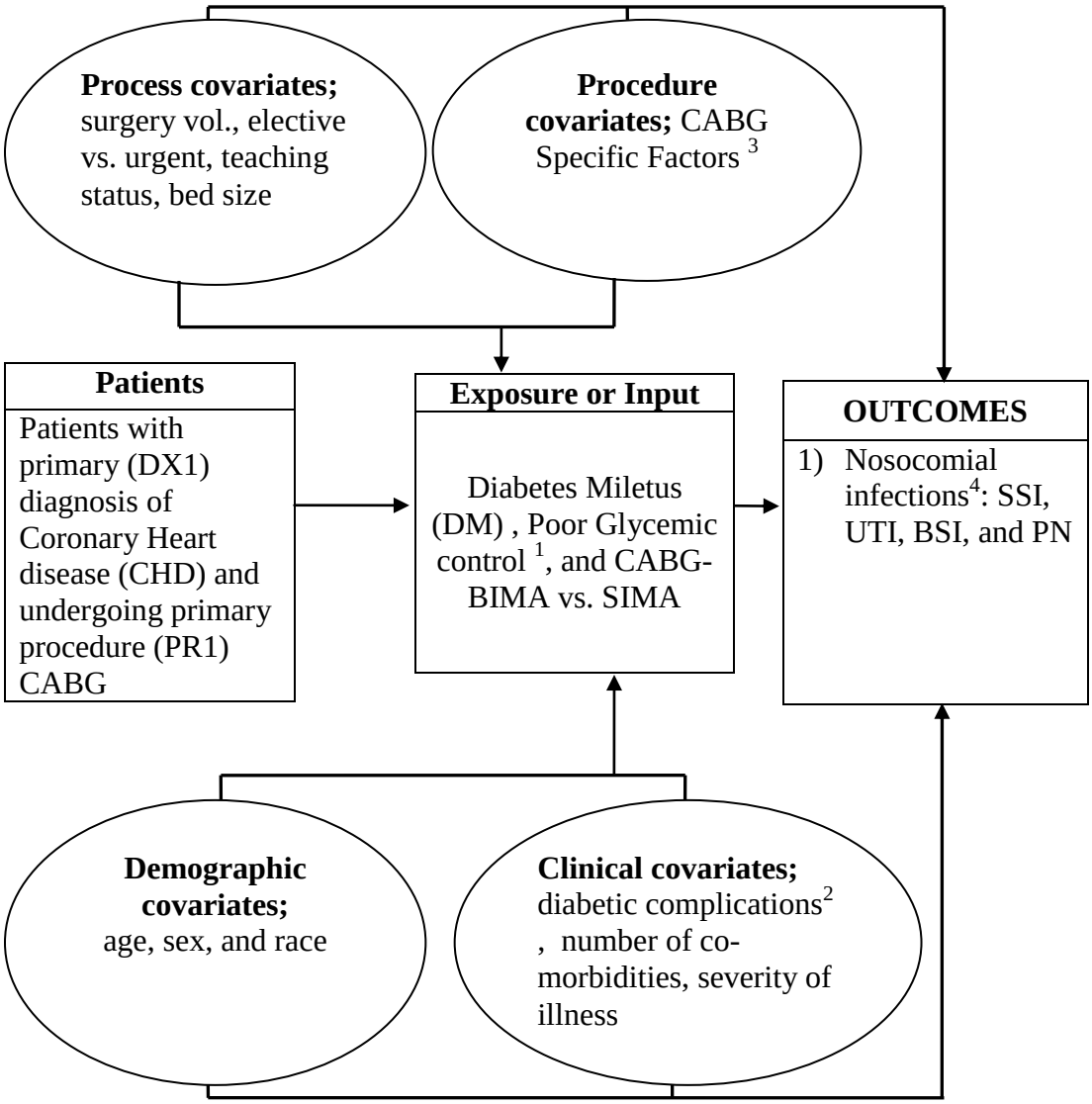
Data used for this study was the Nationwide Inpatient Sample (NIS). The NIS data was developed by the Agency for Healthcare Research and Quality (AHRQ); It is also a part of larger national database called Healthcare Cost and Utilization Project (HCUP). NIS has an annual inpatient discharges data of approximately 8 million hospital stay records from nearly 1000 hospitals in 37 states. Data is collected from 20% of all HCUP-contracted U.S. hospitals and considered one of the largest all-payer inpatient database in United States. NIS data does not include outpatient care and rehabilitation records. NIS provide access to researchers and policy makers about national estimates of healthcare utilization, charges, outcomes, and quality. The NIS data provides a large

sample size which is important for analyzing rare outcomes or targeting special patient's population. The data has all main variables that were needed for this research project to test and analyze the study hypotheses. Each discharge record contains; the primary procedures and diagnoses, all secondary-related procedures and diagnoses, patient demographics, patient admission-to-discharge status, total discharge charges, payment source, length of stay and hospital characteristics. [63]

3.3 Research Design

The study is a retrospective cohort utilization of Nationwide Inpatient Sample (NIS) data. The data was used to extract the overall sample population, which include all patients who underwent Coronary Artery Bypass Grafting (CABG) surgery between 2007 to 2012. Sub-sampling was defined by its exposure in each hypothesis. The hypotheses studied three exposures (predictor or independent) factors; diagnosis of diabetes Miletus, status of hyperglycemic control, and grafting revascularization method used in CABG. The primary outcome (or end-point) of the study was the presence of "Nosicomial infection" during patient hospitalization period for coronary artery bypass grafting surgery. Explanatory (or confounding) variables in analysis were socio-demographic, clinical and hospital factors. The Conceptual Framework of the study was constructed based on Future Research Needs and Gaps identified by AHRQ-Stanford comparative effectiveness research. **[64]** (see Fig. 3)

Figure 3: Conceptual Framework Model of the study.



1 Diabetes with Uncontrolled Hyperglycemia irrespective to the type. 2 Diabetes Complications Subgroups is divided into two types: Acute complications with ketoacidosis, hyperosmolarity, coma; and chronic complication with renal manifestations, ophthalmic manifestation, neurological manifestations, and vascular manifestation. 3 CABG specific factor such as grafting method; Bilateral Internal Mammary Artery (BIMA) grafting, or Single Internal Mammary Artery (SIMA) grafting. **[64]**

3.4 Data Elements:

The NIS discharge files are very detailed on data elements designed by AHRQ

software tools that facilitate the use of the ICD-9-CM coded procedures and diagnoses. The International Classification of Disease, 9th edition, clinical modification (ICD-9-CM) coding system was used to extract the study population, targeted exposures, and outcomes. The NIS data contains 15 procedures and up to 25 diagnoses for each discharge record. Data before 2009 has only 15 diagnoses. NIS data also has a schematic categorization codes for ICD-9-CM called Clinical Classification Software (CCS) used to extract set of ICD-9 codes that define a disease or procedure population. Translation of CCS and ICD-9 codes was retrieved from HCUP website. All indicator variables that were included in the study are represented in (table 3).

Table 3: Description of included variables in national inpatient sample (NIS) data.

HCUP Variables	Description	Coding	Level of measurement
AGE	Age in years at admission	0-124 years old	Continuous
FEMALE	Indicator of sex	0=Male, 1=Female	Nominal
RACE	Race	1=White, 2=Black, 3=Hispanic, 4=Asian or Pacific Islander, 5=Native American, 6=Other	Nominal
DXn	Diagnoses	ICD-9 codes for diagnosis	Nominal
DXCCSn	Clinical Classification Software (CCS) cluster codes for diagnoses ICD-9 codes	259 cluster codes; [49]= all diabetes without complications and [50]= all diabetes with complications	Nominal
PRn	Procedures	ICD-9-codes for procedure	Nominal
PRCCSn	Clinical Classification Software (CCS) cluster codes for procedures ICD-9 codes	231 cluster codes; [44]= all CABG surgeries	Nominal
ATYPE	Admission type	1= Emergency, 2=Urgent 3= Elective, 4= Newborn Other, 5=Trauma Center,	Nominal

		6=Other	
ELECTIVE	Elective versus non-elective admission	0=Non-elective, 1=Elective	Nominal
LOS	Length of Stay	0-365	Continuous
NCHRONIC	number of chronic conditions	0-30	Ordinal
APRDRG_Risk_mortality	Risk of Mortality Subclass	0=No specification, 1=Minor likelihood of dying , 2=Moderate likelihood of dying, 3=Major likelihood of dying , 4=Extreme likelihood of dying	Ordinal
APRDRG_Severity	Severity of Illness Subclass	0=No specification, 1=Minor loss of function, 2=Moderate loss of function, 3=Major loss of function , 4=Extreme loss of function	Ordinal
CM_DM	Diabetes, uncomplicated	0=No, 1=yes	Nominal
CM_CMCX	Diabetes with chronic complications	0=No, 1=yes	Nominal
CM_OBESE	Obesity	0=No, 1=yes	Nominal
CM_AIDS	Acquired immune deficiency syndrome	0=No, 1=yes	Nominal
CM_ANEMDEF	Deficiency anemias	0=No, 1=yes	Nominal
CM_ARTH	Rheumatoid arthritis/collagen vascular diseases	0=No, 1=yes	Nominal
CM_BLDLOSS	Chronic blood loss anemia	0=No, 1=yes	Nominal
CM_CHF	Congestive heart failure	0=No, 1=yes	Nominal
CM_CHRNLUNG	Chronic pulmonary disease	0=No, 1=yes	Nominal
CM_COAG	Coagulopathy	0=No, 1=yes	Nominal
CM_DEPRESS	Depression	0=No, 1=yes	Nominal
CM_DRUG	Drug abuse	0=No, 1=yes	Nominal
CM_HTN_C	Hypertension (combine uncomplicated and complicated)	0=No, 1=yes	Nominal
CM_HYPOTHY	Hypothyroidism	0=No, 1=yes	Nominal
CM_LIVER	Liver disease	0=No, 1=yes	Nominal
CM_LYMP	Lymphoma	0=No, 1=yes	Nominal
CM_LYTES	Fluid and electrolyte disorders	0=No, 1=yes	Nominal
CM_METS	Metastatic cancer	0=No, 1=yes	Nominal
CM_NEURO	Other neurological disorders	0=No, 1=yes	Nominal

CM_PARA	Paralysis	0=No, 1=yes	Nominal
CM_PERIVASC	Peripheral vascular disorders	0=No, 1=yes	Nominal
CM_PSYCH	Psychoses	0=No, 1=yes	Nominal
CM_PULMCIRC	Pulmonary circulation disorders	0=No, 1=yes	Nominal
CM_RENLFAIL	Renal failure	0=No, 1=yes	Nominal
CM_TUMOR	Solid tumor without metastasis	0=No, 1=yes	Nominal
CM_ULCER	Peptic ulcer disease excluding bleeding	0=No, 1=yes	Nominal
CM_VALVE	Valvular disease	0=No, 1=yes	Nominal
CM_WGHTLOSS	Weight loss	0=No, 1=yes	Nominal

3.5 Sample population:

The study cohort was extracted from all patients who underwent Coronary Artery Bypass Grafting (CABG) surgery between 2007 and 2012 by selecting the CCS cluster code "44" from all procedures variables (PRCCS1 to PRCCS15). The CCS "44" is a cluster code that contains all CABG-related ICD-9 codes: 3610, 3611, 3612, 3613, 3614, 3615, 3616, 3617, 3618, 3619, 3619, 363, 3631, 3632, 3633, 3634, 3639. After extracting the sample cases, all discharge records with missing age, gender, and race were eliminated to overcome any potential problem in the descriptive and inferential analysis. Because, these auxiliary variables are important covariates in weighting the sample for chi-square and regression analysis.

3.6 Measurement of Exposure Variables:

The cohort of the study was sorted and organized into groups based on the predictor variables to compare and test the hypotheses. The comparison was stratified based on the use of grafting methods ICD-9-codes; Bilateral Internal Mammary Artery (BIMA: ICD9-3616) and Single Internal Mammary Artery (SIMA: ICD9-3615). Other

grafting methods were excluded such as abdominal-coronary bypass (ICD9-3617), aortic-coronary bypass (ICD9: 3610, 3611, 3612, 3613, 3614) and other bypass gratings ICD-3619, 363, 3631, 3632, 3633, 3634, 3639).

The diagnosis of Diabetes Miletus (DM) was identified in NIS data with any ICD-9 codes (249.xx-250.xx) (from DX1 to DX15) which include; type I, II, and secondary diabetes according to the Clinical Classification Software file under category [CCS=49] and [CCS=50], which include diabetes with and without complications (see Figure 4.).

To identify patients with poor hyperglycemic control, the following ICD-9-CM codes were selected: 250.10-250.13, 250.20-25023, 251.0, and 249.10-249.21, according to the definition of the Center for Medicare and Medicaid Services (CMS) Final Rule, fiscal year (FY) 2009. These codes include patients exposed to Diabetes Miletus diagnosis (DXn) and stated as uncontrolled with complications of acute hyperglycemia. Also, the ICD-9 codes of abnormal level of blood glucose HbA1c; 79021 79022 79029 79099 7964 were included as sensitivity codes. **[65] ,[66]**

3.7 Measurement of Outcomes variables

The endpoints of interest were the nosocomial or healthcare-acquired infections (HAIs) that patients contract during hospitalization. Screening for HAI incidences using National Nosocomial Infection Surveillance System (NNIS) criteria was matched with discharge ICD-9-CM codes. Nosocomail Infections criteria fall into four main infection including: surgical site infection (SSI), pneumonia, urinary tract infection UTI, and sepsis/or blood-stream infections (BSIs). Infectious complications ICD-9-Codes were identified according to pervious publications using NIS data on same endpoints. The

AHRQ-Patient Safety Indicators guidelines, (CMS) Final Rules, fiscal year (FY) 2009, and the relevant studies in literature were reviewed to determine the most sensitive and reliable indicator ICD-9 codes related to nosocomial infections. The following set of ICD-9 codes were used to identify the endpoints: 519.2, 996.60, 996.61, 996.62, 998.31, 998.32, 998.5, 998.51, 998.59, 998.83 — for surgical site infection (SSI); 997.3, 997.31, 997.39, 480.x, 481, 482.xx, 483.x, 484.x, 485, 486, 487.0 — for pneumonia; 038.xx, 785.52, 790.7, 995.9, 995.91, 995.92, 996.60, 996.61, 996.62, 998.0, 999.3, 999.31, 999.39 — for sepsis/or blood stream infection (BSI); 599.0, 996.64 — for urinary tract infection (UTI). **[67], [68], [69] ,[70]**

3.8 Statistical Analysis:

The NIS data was investigated to compare the incidence rate of the nosocomial infectious between the exposure groups. In order to analyze the study assumptions, first the descriptive statistics was performed to report the study cohort characteristics of the main variables including demographics (age, race, and sex), independent, and dependant variables. Categorical variables were described by proportions and percentage. Age was the only continuous variable and was described by mean and standard deviation. The univariate analysis was used to describe the central tendency of the variables and report the cohort's distribution.

Hypotheses on finding the statistical difference about the independent risk variables and their association to outcomes or response variables, were tested by Bivariate test with chi-square goodness of fit to evaluate the differences between the independent risk variables. Chi-square test was used because variables that involved in

the hypotheses analysis were binomial categorical variables. The logistic regression model was used for the study exposures variables, to determine the adjusted odd ratios (ORs) in predicting the nosocomial infections in CABG surgery.

The adjusted analysis was controlled for covariate variables including patient's demographics (age, race, and gender) and 29 HCUP prognostic co-morbidities. It is well known co-morbidity index used in literature to adjust for severity of illness and prediction of outcomes in administrative database. The co-morbidities ICD-9 codes were identified from HCUP CM comorbidity software. Statistical tests were performed two-sided at significance level $p < 0.05$. The descriptive and inferential analyses will be performed using SAS 9.4 software (SAS Institute, Cary, NC).

3.9 Data Handling and Pre-processing:

The study cohorts and the analysis groups were extracted using "ARRAY and DO OVER" loop statement. The diagnoses related to cohort groups were re-coded by "IF and THEN" statement to create binary new variables of the targeted exposure, outcome, and co-morbidities cohorts with (0/1) indictor function in the analysis dataset. These variables correspond to the presence and absence of the matched ICD-9 codes as 1 (yes) and 0 (no). All variables included in the study as indicators were categorical (yes/no) for diabetes group, CABG-BIMA grafting, CABG-SIMA grafting, off-pump CABG, on-pump CABG, targeted types of nosocomial infections outcome that donated as "1" and "0" in the data. "PROC SURVEYMEAN" and "PROC UNIVARIATE" statements were used to describe the variables central tendency and distribution. The PROC SURVEYFREQ statement with "Chisq" option was used for the bivariate analysis and to

determent the Chi-square p-value of the null hypotheses. Sample discharge weight was used to provide national representative estimates using (DISCWT) variable as recommended by HCUP methods of analysis. The STRATA and CLUSTER statements were used to form clustered stratified sample for calculations by using NIS strata variable "NIS_STRA" and cluster identification variable "HOSPID".

CHAPTER 4

RESULTS

4.1 Sample Characteristics:

Between 2007 and 2012, a total of 286,487 patients underwent Coronary Artery Bypass Grafting (CABG) surgery out of 47,133,557 patients discharge records in the NIS data included that period. In the entire study cohort, the average age was in 66 (SD ±10.89) years old in all patients and sample percentile range between age 40 and 93 years old. (see fig. 4)

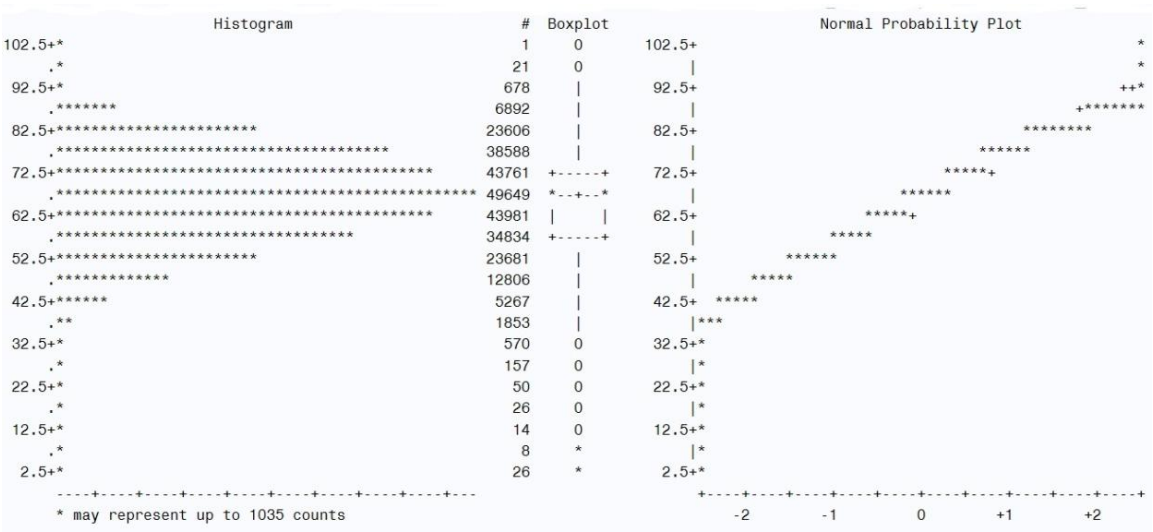


Figure 4. Age distribution in sample population.

Approximately three-quarter of the study population was white (66.61%) and male (72.08%) in patients (Fig. 5 & 6). The results (Fig.7) showed 42.81% (n=122,642) of CABG patients suffered Diabetes Mellitus (DM), of whom 14.73% (n=18,065) had poor hyperglycemic control (HbA1c).

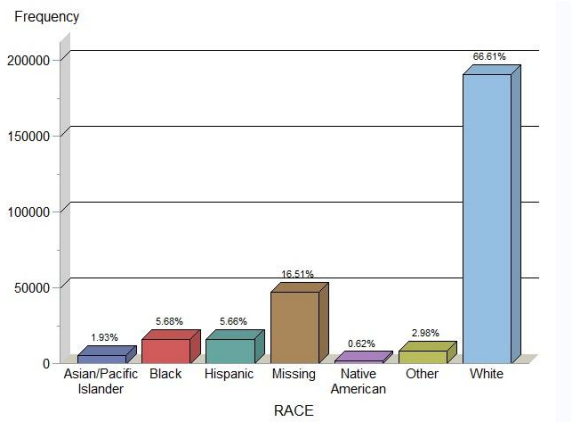


Figure 5. Race distribution in sample population.

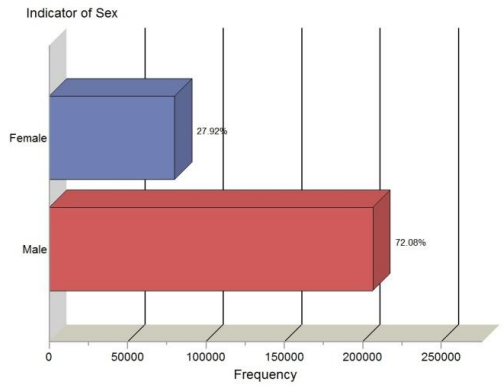
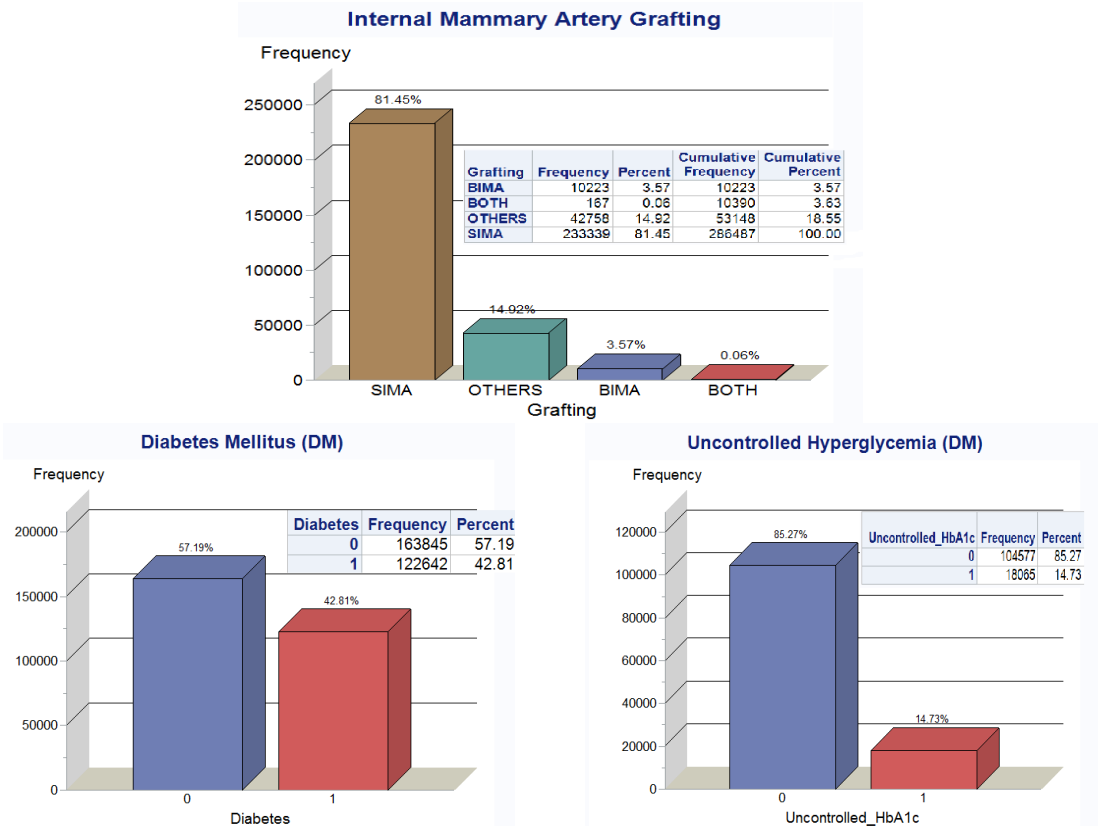


Figure 6. Sex distribution in sample population.

Among patients who underwent CABG surgery; there were 10,390 (3.63%) cases received Bilateral Internal Mammary Artery Grafting (BIMA), 233,339 (81.45%) received Single Internal Mammary Artery Grafting (SIMA), 167 (0.06%) patients had both, and 42,591 (14.92%) had other grafting methods.



Grafting	Frequency	Percent	Cumulative Frequency	Cumulative Percent
BIMA	10223	3.57	10223	3.57
BOTH	167	0.06	10390	3.63
OTHERS	42758	14.92	53148	18.55
SIMA	233339	81.45	286487	100.00

Diabetes	Frequency	Percent
0	163845	57.19
1	122642	42.81

Uncontrolled_HbA1c	Frequency	Percent
0	104577	85.27
1	18065	14.73

Figure 7. Exposure groups distribution in sample population.

Table 4. shows the variability of demographic characteristic among the exposure cohorts. Demographics proportions were consistent in subgroup cohorts with the overall cohort population. Diabetic patients were predominantly white-male and frequently older than 65 years old. Patients undergoing CABG surgery received Bilateral Internal Mammary Artery less frequently than other revascularization techniques.

Table 4: General characteristics of study cohorts for patients undergoing Coronary Artery Bypass Grafting (CABG) surgery from 2007 to 2012.

Characteristics	Overall Cohort	Diabetes	Uncontrolled (HbA1c)	BIMA Grafting Only	SIMA Grafting Only
Patients Demographics					
Age (mean, SD)	66.0±10.89	65.2 ±10.36	62.3 ±10.58	60.9±10.83	65.7 ±10.70
Ages n (%)					
18-34	791(0.25)	261 (32.9)	80 (10.1)	59 (7.4)	550 (69.5)
35-44	7,120(2.5)	3,019 (42.4)	781 (10.9)	559 (7.9)	5,695 (79.9)
45-54	36,487(12.73)	16,180 (44.3)	3,371 (9.2)	2,253 (6.2)	30,364 (83.2)
55-64	78,815 (27.51)	36,678 (36.5)	6,091 (7.7)	3,692 (4.7)	65,753 (83.4)
65-74	93,410 (32.6)	41,675 (44.6)	5,294 (5.7)	2,571 (2.8)	76,973 (82.4)
≥75	69,786 (24.33)	24,818 (35.6)	2,105 (3)	1,251 (1.8)	54,130 (77.6)
Missing	18 (.006)	9 (50)	0	2 (11.1)	15 (83.3)
Gender n (%)					
Male	206,501 (72)	85,988 (41.7)	11,959 (5.8)	8,575 (4.2)	170,422 (82.6)
Female	79,970 (28)	36,649 (45.9)	6,106 (7.5)	1,813 (2.3)	63,073 (78.9)
Missing	16 (.005)	5 (31.3)	0	2 (12.5)	11 (68.75)
Race n (%)					
White	190,831 (66.61)	77,992 (40.9)	10,744 (5.6)	6,462 (3.4)	155,437 (81.5)
Black	16,268(5.68)	8,071(49.6)	1,480 (9.1)	465(2.9)	13,289 (81.7)
Hispanic	16,228(5.66)	9,265 (57.1)	1,667 (10.3)	429(2.7)	13,579 (83.7)
Asian	5,534(1.93)	3,010 (54.4)	330 (5.9)	162(2.9)	4,650 (84.1)
Native	1,780(0.62)	870 (48.9)	140 (7.9)	42(2.4)	1,487 (83.6)
Other	8,545(2.98)	4,184 (48.9)	594 (6.9)	432(5.1)	6,944 (81.3)
Missing	47,301 (16.51)	19,250 (40.7)	3,110 (6.6)	2,398 (5.1)	38,120 (80.6)
Total (%)	**N=286,487**	**n=122,642**	**n=18,065**	**n=10,223**	**n=233,339**

4.2 Overall Rates Of Nosocomial Infection Complications:

The rate of nosocomial infectious complications was predominantly counted for nosocomial pneumonia. About (75.31%) of patients in the sample population had

developed pneumonia at some point during admission. Pneumonia proportion predominated over other types of nosocomial infections. Other infections were less frequent compare to pneumonia, which include urinary tract infections (UTIs) n=16,667 (5.82%), sepsis or blood stream infection (BSIs) n=9,442 (3.3%), and surgical site infection (SSIs) n=5,302 (1.85%). (see fig.9).

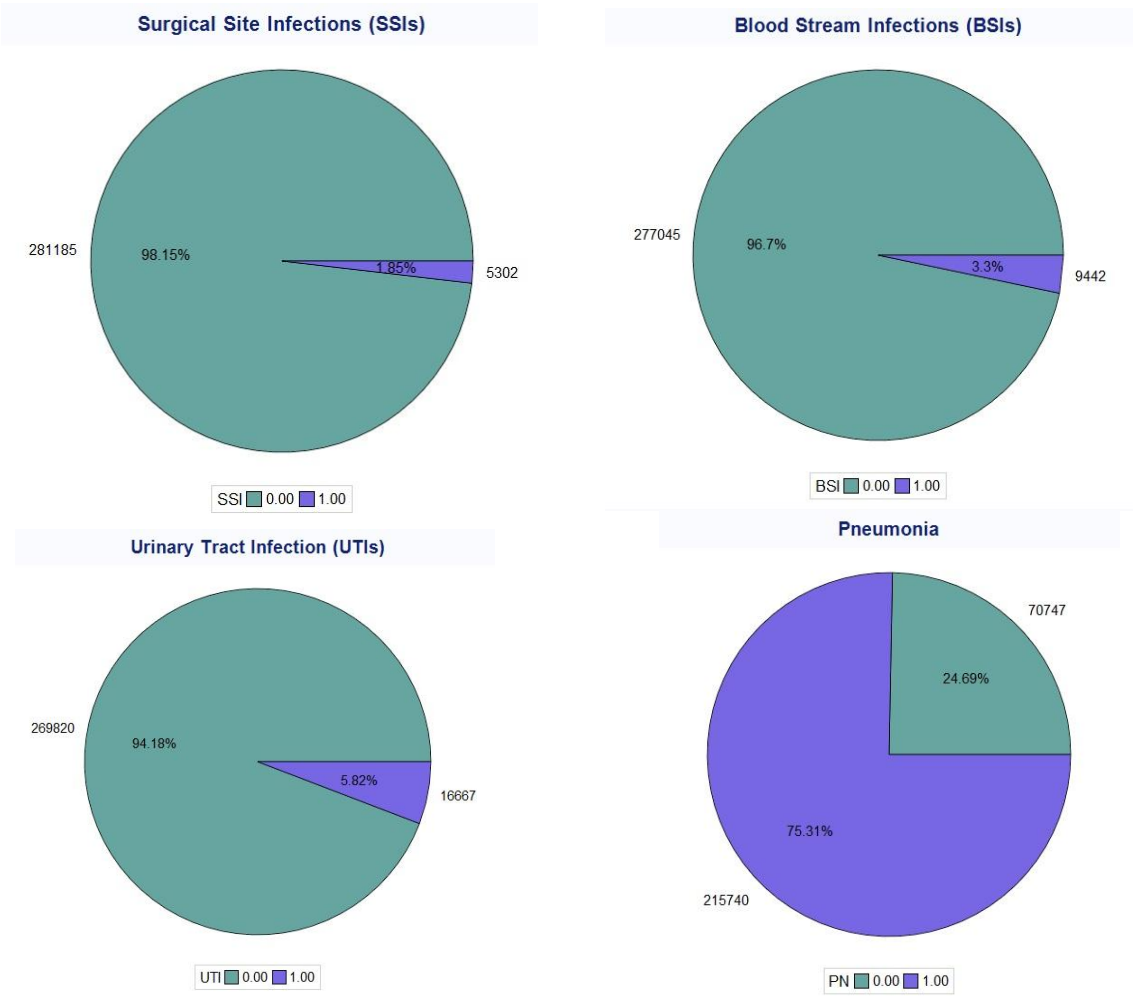


Figure 8. Prevalence and Distribution of Nosocomial Infections in overall sample.

The prevalence of nosocomial infections decreased significantly from 2007 to 2012. The national trend of nosocomial infections noticeable declined in all infections from 2009 to 2010. The rates stayed lower till 2012 in all infections. From 2009 to 2010

there was 8.47% decrease in surgical site infection (SSI), 6.14% decrease in urinary tract infection (UTI), 5.22% in blood stream infection (BSI), and 3.68% decrease in pneumonia. (fig. 9)

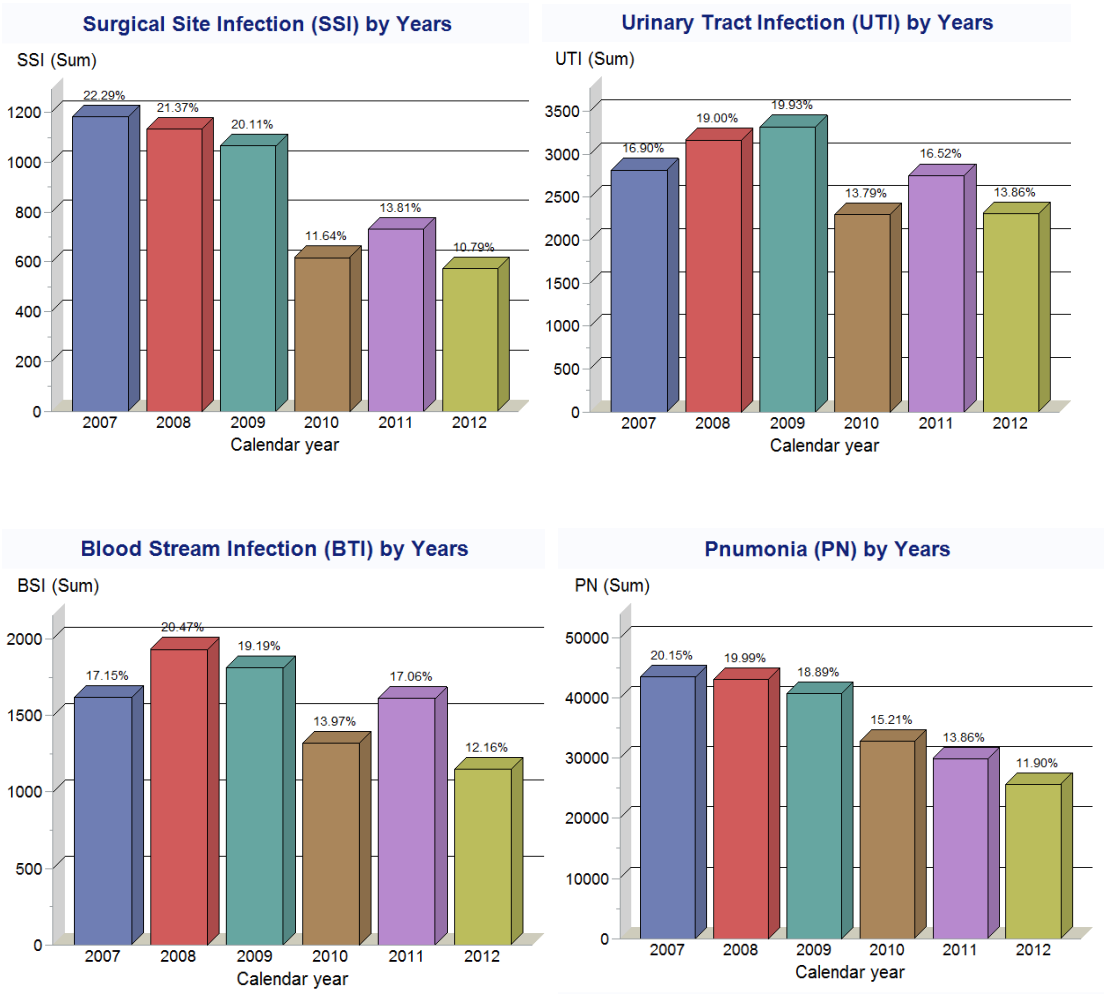


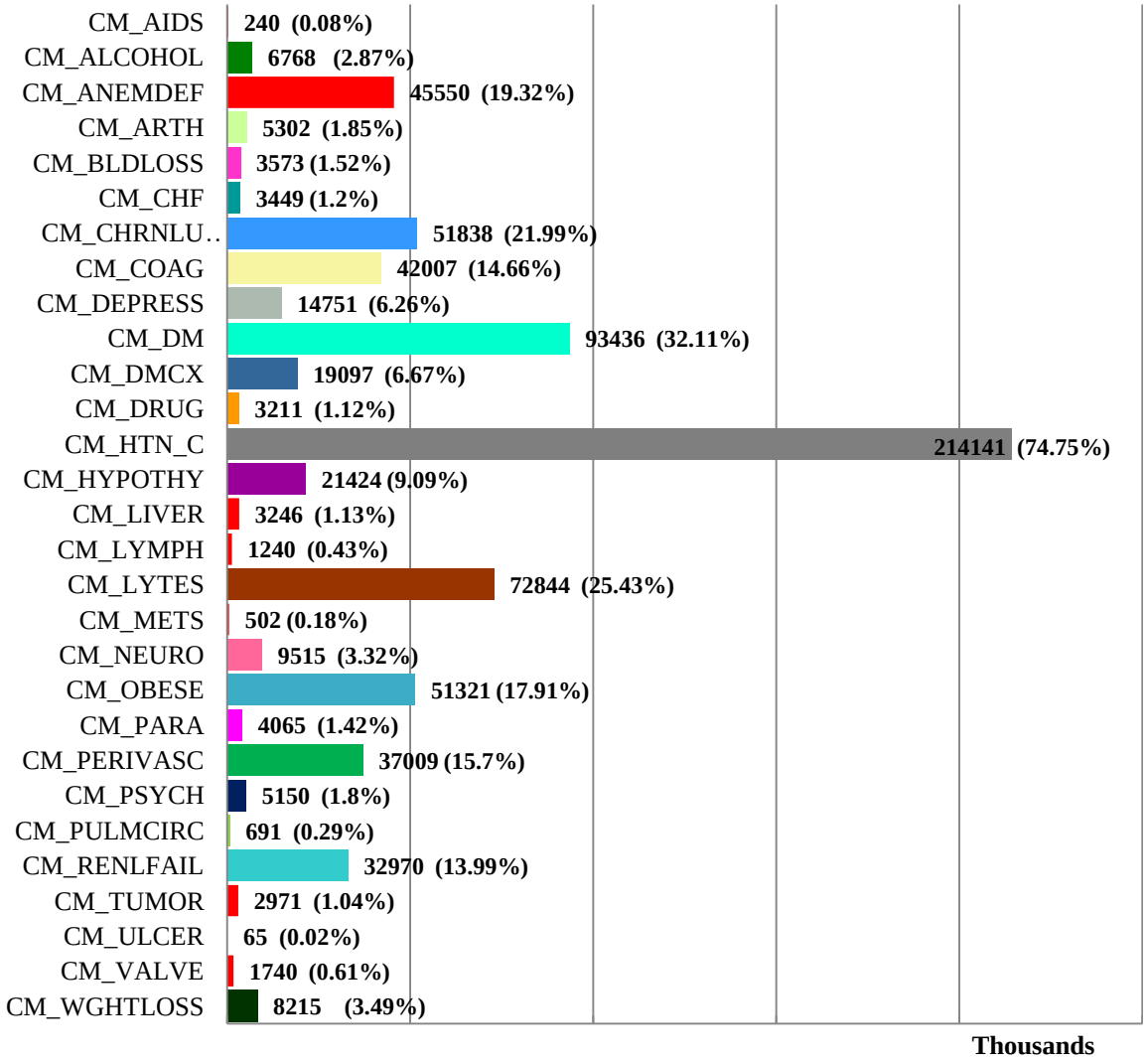
Figure 9. Years-adjusted Prevalence and distribution of Nosocomial Infections (NIS data from 2007-2012).

4.3 Overall Rates Of Comorbidity Risk Factors And Score Of Illness: (Cofounders)

The overall rate of comorbidities and severity of illness scores were calculated as part of our descriptive analysis for the possible cofounder variables. The most common

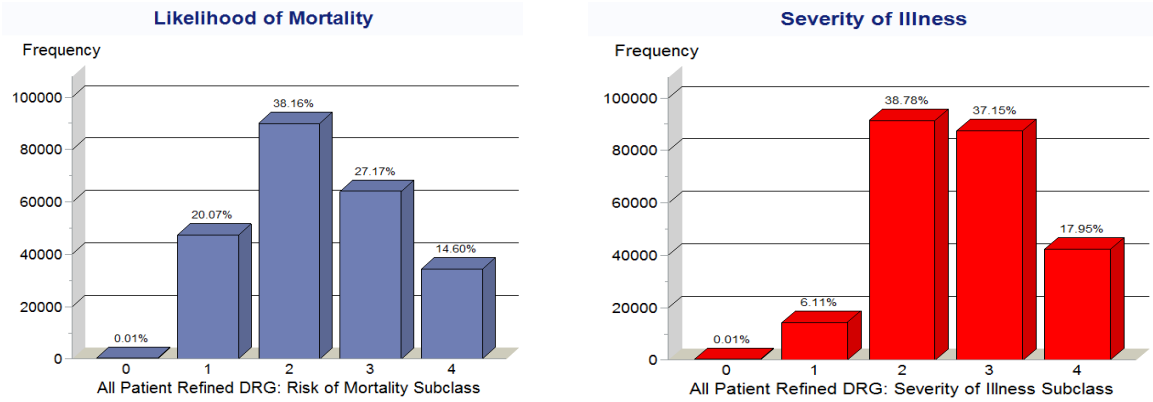
co-morbid diseases in CABG population [N=286,487] are blood hypertension (**74.75%**) and diabetes mellitus (**38.78%; 32.11%** uncomplicated, **6.67%** complicated).

Figure 10. Distribution of Co-morbidities in CABG population in NIS data (2007-2012).



CM_AIDS*:** Acquired immune deficiency syndrome, ***CM_ALCOHOL*:** Alcohol abuse, ***CM_ANEMDEF*:** Deficiency anemias, ***CM_ARTH*:** Rheumatoid arthritis/collagen vascular diseases, ***CM_BLDLOSS*:** Chronic blood loss anemia, ***CM_CHF*:** Congestive heart failure, ***CM_CHRNLUNG*:** Chronic pulmonary disease, ***CM_COAG*:** Coagulopathy, ***CM_DEPRESS*:** Depression, ***CM_DM*:** Diabetes, uncomplicated, ***CM_DMCX*:** Diabetes with chronic complications, ***CM_DRUG*:** Drug abuse, ***CM_HTN_C*:** Hypertension (combine uncomplicated and complicated), ***CM_HYPOTHY*:**Hypothyroidism, ***CM_LIVER: Liver disease, ***CM_LYMPH*:** Lymphoma, ***CM_LYTES*:**Fluid and electrolyte disorders, ***CM_METS*:**Metastatic cancer, ***CM_NEURO*:** Other neurological disorders, ***CM_OBESE*:** Obesity, ***CM_PARA*:** Paralysis, ***CM_PERIVASC*:** Peripheral vascular disorders, ***CM_PSYCH*:** Psychosis**,** ***CM_PULMCIRC*:** Pulmonary circulation disease, ***CM_RENLFAIL*:** Renal Failure**,** ***CM_TUMOR*:** Solid tumor without metastasis**,** ***CM_ULCER*:** Peptic ulcer disease excluding bleeding**,** ***CM_VALVE*:** Valvular disease**,** ***CM_WGHTLOSS*:** Wight loss**.**

The prevalence of other co-morbidies are ranked retrospectively as follow; **25.43%** for Fluid And Electrolyte Disorders, **21.99%** for Chronic Pulmonary Disease, **19.32%** for Deficiency Anemia, **17.91%** for Obesity, **15.7%** for Peripheral Vascular Disorders, **14.66%** for Coagulopathy, **13.99%** for Renal Failure, **9.09%** for Hypothyroidism, and **6.26%** for Depression. (see fig. 10) The score in severity of illness measure the loss of function in the patients. About 75% of CABG population fall between moderate to major loss of function as indicator for severity of illness. Also about 65% of CABG patients are at risk of death. (see fig.11)



All Patient Refined DRG: Risk of Mortality Subclass				
APRDRG_Risk_Mortality	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	20	0.01	20	0.01
1	47307	20.07	47327	20.08
2	89940	38.16	137267	58.23
3	64034	27.17	201301	85.40
4	34420	14.60	235721	100.00
Frequency Missing = 50766				

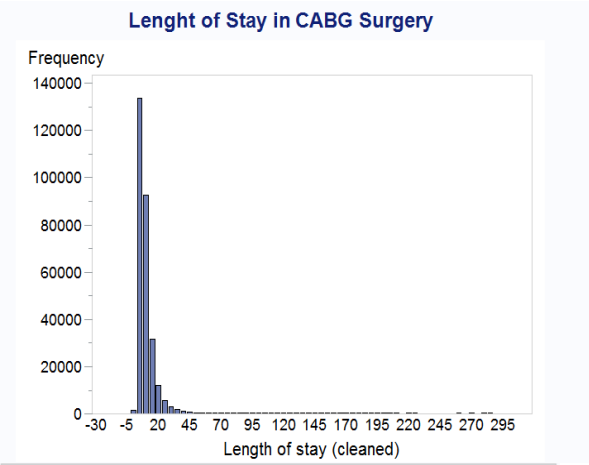
All Patient Refined DRG: Severity of Illness Subclass				
APRDRG_Severity	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	20	0.01	20	0.01
1	14407	6.11	14427	6.12
2	91411	38.78	105838	44.90
3	87561	37.15	193399	82.05
4	42322	17.95	235721	100.00
Frequency Missing = 50766				

Figure 11. Distribution Score for Severity of Illness and risk of mortality in CABG population in (NIS data ; from 2007-2012).

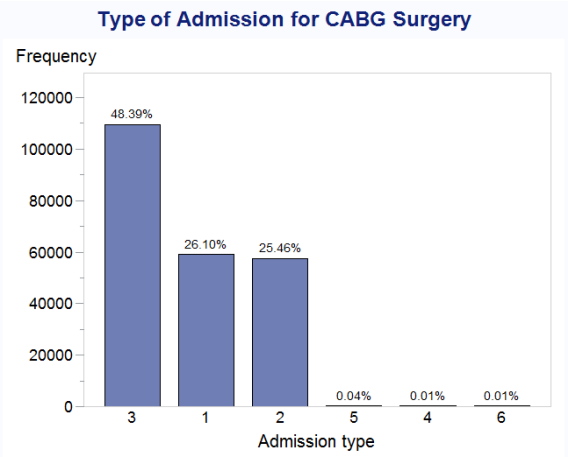
4.4 Distribution Of Important Hospital Factors In CABG Population: (Cofounders)

Length of stay as cofounder variable plays important role in increasing the patient exposure to the risk of healthcare-related infections. The univariate analysis shows that

patients undergoing CABG surgery are usually stayed between 10 - 45 days in hospital. Average LOS is about 10 days. It is based on a combined average length of stay from 2008 to 2012. Another important hospital factor is admission type. It indicates whether admission was emergency (score: 1) , urgent (score; 2), or elective (score; 3) for CABG procedure. The descriptive result shows that about half (51%) of CABG population undergo emergency or urgent admission. Urgent or emergency intervention could increase risk of infection. (see fig. 12)



Analysis Variable : LOS Length of stay (cleaned)						
Mean	Std Dev	Minimum	Maximum	N	Lower 95% CL for Mean	Upper 95% CL for Mean
9.9093789	17.9518008	0	283.0000000	286482	9.8797975	9.9389602



Analysis Variable : AGE Age in years at admission								
Admission type	N Obs	Mean	Std Dev	Minimum	Maximum	N	Lower 95% CL for Mean	Upper 95% CL for Mean
1	59075	64.9287851	25.4820970	0	98.0000000	59069	64.8364529	65.0211173
2	57624	65.8857100	24.6618102	0	96.0000000	57622	65.7952348	65.9761853
3	109537	66.5142541	23.2506522	0	98.0000000	109529	66.4523229	66.5761854
4	17	63.0447171	23.2207556	41.0000000	82.0000000	17	57.6419794	68.4474548
5	84	63.5467205	32.5015078	15.0000000	87.0000000	84	60.3362749	66.7571662
6	17	64.2479366	21.8296557	42.0000000	82.0000000	17	59.1493546	69.3465186

Figure 12. CABG Patients Hospital length of study and type of admission. (NIS data ; from 2007-2012).

4.5 Significance Of The Association Between Exposures And Nosocomial Infections:

Initially, we used the bivariate analysis (X^2 contingency table) to test the hypotheses and show the significance of the association between the targeted exposures

and the outcomes. The cross unadjusted rates of nosocomial infections were tested by Pearson chi-square test in exposed patients compared to those not exposed using "PROC FREQ" SAS procedure. If the Chi-Square probability (p-value) less than (< 0.05), the null hypotheses were rejected to consider the relationship as significant between the exposures (Diabetes Mellitus, Poor glycemic control, Bilateral Internal Mammary Grafting surgery) and nosocomial infections. Accepting the alternative hypotheses indicate the association between the exposure variables and outcomes compared to the control groups. The observation percentages (row Pct.) for the outcomes were reported and whether significantly lower or higher with the presence of the exposures in each hypothesis.

4.5.1 Evaluation Of Hypothesis A (Research Q.1): *Hypothesis A (Assumption) — "BIMA grafting has higher rates of nosocomial infections than SIMA grafting in CABG population."*

In overall CABG patients, the rate of surgical site infections, blood stream infections and urinary tract infections were significantly lower in Bilateral Internal Mammary Artery (BIMA) grafting compared to Single Internal Mammary Artery (SIMA). However, BIMA grafting was associated with higher rate of 2pneumonias. The null hypothesis was rejected in all nosocomial infections comparing BIMA versus SIMA; surgical site infection (SSI) (1.40% vs. 1.69%); p=0.0332 , urinary tract infections (UTI) (3.68% VS 5.69%); p<.0001, blood stream infections BSI: (2.39VS 2.84) p= 0.0071, and pneumonia PN: (83.4% VS 75.9%) p<.0001. The null hypothesis was rejected with p-value less than alpha=0.05 in comparing the rate of nosocomial infections. The results have indicated that BIMA grafting method. However, results did not meet the hypothesis

assumption regarding Pneumonias rate (% vs. 68.5%; p-value < 0.0001) and was significantly higher with BIMA than SIMA grafting or anastamosis method (see table 5).

Table 5: Comparison of unadjusted rates of nosocomial infections between BIMA and SIMA revascularization in overall CABG population from 2007 to 2012. [N=286,487]				
Outcomes	Presence of revascularization techniques n (% obs. percentage or row Pct.)			
	%BIMA n=10,223	%SIMA n=233,339	*Total* N=243,562	*p*-value
Surgical Site Infections (SSIs)	1.4	1.7	4,049	0.0332
Urinary Tract Infections (UTIs)	3.7	5.7	13,644	<.0001
Blood Stream Infections (BSIs)	2.4	2.8	6,863	0.0071
Pneumonias (PNs)	83.4	75.9	185,847	<.0001

4.5.2 Evaluation Of Hypothesis A.b (Research Q.2): *(Assumption) — "BIMA grafting has higher rates of nosocomial infections rate than SIMA grafting in Diabetic-CABG population"*

Among diabetic patients (n=122,642) undergoing CABG surgery, there were n=3,700 diabetics underwent BIMA grafting and n=103,577 underwent SIMA grafting during CABG surgery. There was no significant difference in the rate of surgical site infections and blood stream infections by comparing the two internal mammary grafting methods; Single Internal Mammary Artery (SIMA) and Bilateral Internal Mammary Artery (BIMA). Which means null hypothesis was accepted in comparing BIMA versus SIMA for surgical site infection (SSI) (1.04% vs. 1.26%; p-value=0.2491) and blood stream infections (1.45% vs. 1.54%; p-value=0.6630)**.**

The null hypothesis was rejected with p-value less than alpha=0.05 in comparing the rate of other nosocomial infections. The results indicated urinary tract infection UTIs was significantly (4.2% vs. 5.9%; p-value=0.0008) lower with BIMA grafting method. The result met the hypothesis assumption that Pneumonias rate (76.9% vs. 68.5%; p-

value < 0.0001) was significantly higher with BIMA compared to SIMA grafting or anastamosis method (see table 6). BIMA grafting was associated with higher pneumonias rate compared to SIMA grafting, which was consistent also with previous main hypothesis in total CABG population.

Table 6: Unadjusted rates of nosocomial infections between patients with BIMA and SIMA revascularization techniques in diabetic patients undergoing CABG from 2007 to 2012. [N=122,642]

Outcomes	Presence of revascularization techniques n (% obs. percentage or row Pct.)			
	%BIMA n=3,700	%SIMA n=103,577	*Total* N=107,226	*p*-value
Surgical Site Infections (SSIs)	1.04	1.26	1,340	0.2491
Urinary Tract Infections (UTIs)	4.19	5.52	5,868	0.0005
Blood Stream Infections (BSIs)	1.45	1.54	1,651	0.6630
Pneumonias (PNs)	76.82	70.49	75,817	<.0001

4.5.3 Evaluation Of Hypothesis B (ResearchQ.3): *(Assumption) — " Diabetic patients have significantly higher rate of nosocomial infections than non-diabetic patients. (in total CABG, BIMA only, and SIMA only)"*

The null hypothesis was rejected at alpha=0.05. The cross unadjusted baseline results for all nosocomial infections rates were significantly lower in diabetic patients compared to non-diabetic. The results did not meet our hypothesized assumption that diabetics have higher rates of all nosocomial infections, expect for urinary tract infections rates (UTIs) in BIMA grafting cases; (4.19% vs. 3.39%; p-value=0.0219). In BIMA grafting, diabetes was associated with higher rate of UTIs. The rows or observations percentages for the outcomes were reported in 2X2 table (diabetes DM vs. no-diabetes NDM) as follow in (Table 7,8&9).

Table 7: The unadjusted rates of nosocomial infections by Diabetes in total CABG population from 2007 to 2012. [N=286,487]				
Outcomes	Presence of Diabetes n (% obs. percentage or row Pct.)			
	Diabetes n=122,642	No-Diabetes n= 163,845	*Total* **N=286,487**	*p*-value
Surgical Site Infections (SSIs)	1.35	2.23	5,302	<.0001
Urinary Tract Infections (UTIs)	5.55	6.02	16,667	<.0001
Blood Stream Infections (BSIs)	1.7	4.49	9,442	<.0001
Pneumonias (PNs)	69.78	79.44	215,740	<.0001

Table 8: The unadjusted rates of nosocomial infections by Diabetes in CABG-SIMA grafting population from 2007 to 2012. [n=233,339]				
Outcomes	Presence of Diabetes n (% obs. percentage or row Pct.)			
	Diabetes n=103,577	No-Diabetes n= 129,762	*Total* **N=233,339**	*p*-value
Surgical Site Infections (SSIs)	1.26	2.01	3,906	<.0001
Urinary Tract Infections (UTIs)	5.52	5.82	13,268	0.0017
Blood Stream Infections (BSIs)	1.54	3.87	6,619	<.0001
Pneumonias (PNs)	70.49	80.38	177,319	<.0001

Table 9: The unadjusted rates of nosocomial infections by Diabetes in CABG-BIMA grafting population from 2007 to 2012. [n=10,223]				
Outcomes	Presence of Diabetes n (% obs. percentage or row Pct.)			
	Diabetes n=3,649	No-Diabetes n= 6,574	*Total* **N=10,223**	*p*-value
Surgical Site Infections (SSIs)	1.04	1.60	143	0.0219
Urinary Tract Infections (UTIs)	4.19	3.39	376	0.0393
Blood Stream Infections (BSIs)	1.45	2.91	244	<.0001
Pneumonias (PNs)	76.82	87.09	8,528	<.0001

4.5.4 Evaluation Of Hypothesis C (Research Q.4): *(Assumption) — "Diabetic patients with poor hyperglycemic control undergoing CABG surgery have higher rate of nosocomial infections than patients with controlled diabetes (in total CABG, BIMA only, SIMA only)"*

This hypothesis is testing whether the effect of uncontrolled hyperglycemia (HbA1c) on nosocomial infections is significant or not in diabetic patients undergoing CABG surgery. The hypothesis was tested at alpha level 0.05. The null hypothesis was rejected in most nosocomial infections. The cross 2x2 table results indicated that nosocomial infections rates were significantly higher in diabetic with uncontrolled HbA1c compared to those with controlled HbA1c in SSI, UTI, and BSIs. Except for

nosocomial pneumonia, did not meet the expectation. It was significantly lower in uncontrolled diabetes group. The rows or observations percentage for the outcomes was as follow (Uncontrolled vs. Controlled) in total CABG population, CABG with SIMA grafting, and BIMA grafting; (see table 10,11.&12).

Table 10: Unadjusted rates of nosocomial infections by uncontrolled hyperglycemia (HbA1c) in diabetic patients in Total CABG population from 2007 to 2012. [N=122,642]				
Outcomes	Presence of uncontrolled (HbA1c) n (% obs. percentage or row Pct.)			
	Uncontrolled HbA1c n=18,065	Controlled HbA1c n=104,577	*Total* **N=122,642**	*p*-value
Surgical Site Infections (SSIs)	1.98	1.24	1,651	<.0001
Urinary Tract Infections (UTIs)	7.77	5.17	6,808	<.0001
Blood Stream Infections (BSIs)	2.50	1.56	2,081	<.0001
Pneumonias (PNs)	59.71	71.52	85,577	<.0001
Table 11: Unadjusted rates of nosocomial infections by uncontrolled hyperglycemia (HbA1c) in diabetic patients in CABG-SIMA grafting population from 2007 to 2012. [n=103,577]				
Outcomes	Presence of uncontrolled (HbA1c) n (% obs. percentage or row Pct.)			
	Uncontrolled HbA1c n=15,645	Controlled HbA1c n=87,932	*Total* **N=103,577**	*p*-value
Surgical Site Infections (SSIs)	1.81	1.16	1,302	<.0001
Urinary Tract Infections (UTIs)	7.71	5.13	5,715	<.0001
Blood Stream Infections (BSIs)	2.23	1.42	1,598	<.0001
Pneumonias (PNs)	60.48	61.36	73,014	<.0001
Table 12: Unadjusted rates of nosocomial infections by uncontrolled hyperglycemia (HbA1c) in diabetic patients in CABG-BIMA grafting population from 2007 to 2012. [n=3,649]				
Outcomes	Presence of uncontrolled (HbA1c) n (% obs. percentage or row Pct.)			
	Uncontrolled HbA1c n=453	Controlled HbA1c n=3,196	*Total* **N=3,649**	*p*-value
Surgical Site Infections (SSIs)	2.21	0.88	38	0.0090
Urinary Tract Infections (UTIs)	6.40	3.88	153	0.0122
Blood Stream Infections (BSIs)	2.43	1.31	53	0.0636
Pneumonias (PNs)	65.34	78.44	2,803	<.0001

4.6 The Exposures Effect and Odd of The Nosocomial Infections (Multivariate Analyses):

In this section, we utilize "PROC LOGISTIC" using the Multiple Logistic regression, to describes the causative relationship between the nosocomial Infections (SSI, UTI, PN, and BSI) and three predictors (diabetes, uncontrolled HbA1c, and BIMA revascularization). The model was adjusted for the following relevant cofounder variables including; age, gender, race, HCUP **CM_ comorbidities** variables, length of stay, number of procedure in record, type of admission, and type of procedure to be elective or non-elective . All these indicators were included in model and summarized in (table 13).

Table 13: Summary of the indicator variables included in Logistic regression model.

		Mean	Std Dev	Min	Max	N	Lower 95% CL for Mean	Upper 95% CL for Mean
AGE		66.01	24.21	0	100	**286469**	65.97	66.05
FEMALE	**0**	65.35	23.84	0	98	**206501**	65.30	65.39
	1	67.73	24.79	0	100	**79970**	67.65	67.80
Reference: Male= '0'								
RACE	**1**	66.64	23.94	0	100	**190831**	66.59	66.69
	2	62.30	24.35	0	98	**16268**	62.13	62.47
	3	64.12	24.56	0	92	**16228**	63.95	64.29
	4	64.46	24.10	1	94	**5534**	64.17	64.75
	5	64.58	24.39	10	89	**1780**	64.08	65.09
	6	64.83	24.57	0	94	**8545**	64.60	65.06
Reference: White= '1'								
ELECTIVE	**0**	65.42	25.06	0	100	**147779**	65.36	65.48
	1	66.65	23.18	0	99	**138034**	66.59	66.70
Reference: elective= '1'								
LOS: Length of Stay		9.90	17.95	0	283	**286482**	9.87	9.93
NCHRONIC: Number of		6.93	6.14	0	26	**235721**	6.92	6.95

Table 13: Summary of the indicator variables included in Logistic regression model.

		Mean	Std Dev	Min	Max	N	Lower 95% CL for Mean	Upper 95% CL for Mean
chronic conditions								
ATYPE: Admission Type	**1**	64.92	25.48	0	98	**59075**	64.83	65.02
	2	65.88	24.66	0	96	**57624**	65.79	65.97
	3	66.51	23.25	0	98	**109537**	66.45	66.57
	4	63.04	23.22	41	82	**17**	57.64	68.44
	5	63.54	32.50	15	87	**84**	60.33	66.75
	6	64.24	21.82	42	82	**17**	59.14	69.34
Reference: Elective= '3'								
APRDRG_ Severity	**0**	68.24	4.73	66	70	**20**	63.01	73.46
	1	62.98	23.52	5	93	**14407**	62.80	63.15
	2	64.70	23.41	0	95	**91411**	64.64	64.77
	3	66.70	24.22	0	100	**87561**	66.62	66.77
	4	68.32	24.53	0	95	**42322**	68.22	68.43
Reference: lowest score severity of illness= '0'								
APRDRG_ Risk_Mortality	**0**	68.24	4.73	66	70	**20**	63.01	73.46
	1	61.46	20.59	0	91	**47307**	61.37	61.54
	2	65.99	24.15	0	95	**89940**	65.92	66.06
	3	67.17	24.38	0	100	**64034**	67.09	67.26
	4	70.02	23.52	0	95	**34420**	69.91	70.13
Reference: lowest score risk of mortality= '0'								
Diabetes	**0**	66.61	24.96	0	100	**163845**	66.55	66.66
	1	65.21	23.04	0	95	**122642**	65.16	65.27
Reference: Absence of Diabetes= '0'								
Uncontrl_HbA1c	**0**	66.26	24.15	0	100	**268422**	66.22	66.30
	1	62.36	23.57	22	95	**18065**	62.20	62.51
Reference: Controlled Diabetes or hyperglycemia (HBA1c)= '0'								
BIMA	**0**	65.78	23.80	0	100	**233339**	65.73	65.82
	1	60.89	23.98	0	93	**10223**	60.68	61.10
Reference: SIMA revascularization= '0'								
SIMA	0	60.89	23.98	0	93	**10223**	60.68	61.10
	1	65.78	23.80	0	100	**233339**	65.73	65.82
Reference: BIMA revascularization= '0'								
CM_AIDS	**0**	66.02	24.20	0	100	**286247**	65.98	66.06
	1	55.82	21.15	27	79	**240**	54.61	57.03
Reference: WITHOUT AIDS= '0'								
CM_ALCOHOL	**0**	66.14	24.15	0	100	**228953**	66.09	66.18
	1	60.78	21.76	20	92	**6768**	60.55	61.02
Reference: UNALCOHOLICH= '0'								
CM_ANEMDEF	**0**	65.78	24.15	0	100	**190171**	65.73	65.83

Table 13: Summary of the indicator variables included in Logistic regression model.

		Mean	Std Dev	Min	Max	N	Lower 95% CL for Mean	Upper 95% CL for Mean
	1	66.86	24.12	0	99	**45550**	66.76	66.96
Reference: WITHOUT DEFECIANY ANEMIA= '0'								
CM_ARTH	**0**	65.98	24.22	0	100	**281185**	65.94	66.02
	1	67.49	23.21	16	98	**5302**	67.21	67.77
Reference: WITHOUT RHEUMATOID ARTHRITIS= '0'								
CM_BLDLOSS	**0**	65.97	24.15	0	100	**232148**	65.93	66.02
	1	66.79	24.71	28	92	**3573**	66.42	67.16
Reference: WITHOUT BLOOD LOSS= '0'								
CM_CHF	**0**	65.97	24.18	0	100	**283038**	65.93	66.01
	1	69.48	25.40	0	95	**3449**	69.10	69.86
Reference: WITHOUT Congestive Heart Failure= '0'								
CM_CHRNLUNG	**0**	66.00	24.55	0	100	**183883**	65.95	66.05
	1	65.94	22.75	0	96	**51838**	65.85	66.03
Reference: WITHOUT Chronic pulmonary disease = '0'								
CM_COAG	**0**	65.51	24.16	0	100	**244480**	65.46	65.55
	1	68.95	23.41	0	95	**42007**	68.85	69.05
Reference: WITHOUT Coagulopathy = '0'								
CM_DEPRESS	**0**	66.13	24.15	0	100	**220970**	66.09	66.18
	1	63.78	23.85	14	94	**14751**	63.61	63.96
Reference: WITHOUT Depression= '0'								
CM_DM	**0**	66.25	24.83	0	100	**193051**	66.20	66.30
	1	65.52	22.83	18	95	**93436**	65.45	65.58
Reference: WITHOUT Diabetes= '0'								
CM_DMCX	**0**	66.14	24.25	0	100	**267390**	66.10	66.19
	1	64.14	23.21	0	92	**19097**	63.99	64.29
Reference: WITHOUT Diabetes with chronic complications = '0'								
CM_DRUG	**0**	66.15	24.06	0	100	**283276**	66.11	66.19
	1	53.55	20.77	23	87	**3211**	53.22	53.87
Reference: WITHOUT history of Drug abuse = '0'								
CM_HTN_C	**0**	65.50	25.66	0	99	**72346**	65.41	65.58
	1	66.18	23.68	0	100	**214141**	66.14	66.23
Reference: No Hypertension= '0'								
CM_HYPOTHY	**0**	65.69	24.13	0	100	**214297**	65.64	65.73
	1	68.98	23.49	27	95	**21424**	68.84	69.13
Reference: WITHOUT Hypothyroidism= '0'								
CM_LIVER	**0**	66.06	24.21	0	100	**283241**	66.02	66.10
	1	61.49	21.47	31	94	**3246**	61.16	61.82
Reference: No Liver disease= '0'								
CM_LYMPH	**0**	66.01	24.20	0	100	**285247**	65.97	66.05
	1	66.63	25.83	20	90	**1240**	65.99	67.28
Reference: No Lymphoma= '0'								

Table 13: Summary of the indicator variables included in Logistic regression model.

		Mean	Std Dev	Min	Max	N	Lower 95% CL for Mean	Upper 95% CL for Mean
CM_LYTES	**0**	65.65	24.09	0	100	**213643**	65.61	65.70
	1	67.06	24.40	0	99	**72844**	66.98	67.14
Reference: WITHOUT Fluid and Electrolyte disorders= '0'								
CM_METS	**0**	65.95	24.19	0	100	**276972**	65.91	65.99
	1	67.74	24.41	0	98	**9515**	67.52	67.96
Reference: No Metastatic cancer= '0'								
CM_NEURO	**0**	66.72	24.29	0	100	**235166**	66.67	66.76
	1	62.77	22.47	0	93	**51321**	62.68	62.86
Reference: No Neurological Disorders= '0'								
CM_OBESE	**0**	66.72	24.29	0	100	**235166**	66.67	66.76
	1	62.77	22.47	0	93	**51321**	62.68	62.86
Reference: No Obesity= '0'								
CM_PARA	**0**	65.99	24.22	0	100	**282422**	65.95	66.03
	1	67.80	22.76	1	95	**4065**	67.48	68.11
Reference: No paralysis = '0'								
CM_PSYCH	**0**	66.05	24.15	0	100	**281337**	66.01	66.09
	1	63.77	26.44	7	98	**5150**	63.44	64.09
Reference: No Psychosis= '0'								
CM_PULMCIRC	**0**	65.98	24.16	0	100	**235030**	65.93	66.02
	1	69.35	24.33	32	91	**691**	68.53	70.17
Reference: WITHOUT Pulmonary circulation disorder= '0'								
CM_RENLFAIL	**0**	65.50	24.09	0	100	**202751**	65.45	65.55
	1	68.99	23.54	2	96	**32970**	68.88	69.11
Reference: No Renal Failure= '0'								
CM_TUMOR	**0**	65.95	24.22	0	100	**283516**	65.91	65.99
	1	71.44	19.56	31	95	**2971**	71.12	71.75
Reference: WITHOUT Solid Tumor= '0'								
CM_ULCER	**0**	66.01	24.21	0	100	**286422**	65.97	66.05
	1	67.80	22.66	40	87	**65**	65.27	70.32
Reference: No peptic Ulcer= '0'								
CM_VALVE	**0**	65.99	24.19	0	100	**284747**	65.95	66.03
	1	70.22	25.21	1	93	**1740**	69.69	70.76
Reference: No Valvular Disease= '0'								
CM_WGHTLOSS	**0**	65.86	24.12	0	100	**227506**	65.82	65.90
	1	69.49	24.05	27	95	**8215**	69.25	69.72
Reference: No Weight loss= '0'								
SSI	**0**	65.98	24.19	0	100	**281185**	65.94	66.02
	1	67.42	24.65	0	93	**5302**	67.13	67.72
Probability modeled is "SSI=1/yes"								
UTI	**0**	65.75	24.13	0	100	**269820**	65.71	65.79
	1	70.23	23.48	0	95	**16667**	70.07	70.39

Table 13: Summary of the indicator variables included in Logistic regression model.								
		Mean	**Std Dev**	**Min**	**Max**	**N**	**Lower 95% CL for Mean**	**Upper 95% CL for Mean**
Probability modeled is "UTI=1/yes"								
BSI	**0**	65.94	24.16	0	100	**277045**	65.90	65.98
	1	68.05	25.16	0	95	**9442**	67.82	68.28
Probability modeled is "BSI=1/yes"								
PN	**0**	67.77	23.86	0	98	**70747**	67.69	67.85
	1	65.43	24.18	0	100	**215740**	65.39	65.48
Probability modeled is "PN=1/yes"								

The overall sample was weighted with nationwide discharge weight (DISWT) before executing the multivariate analysis and the results were as following;

4.6.1 The effect of Bilateral Internal Mammary Artery (BIMA) Grafting:

Hypothesis A (Assumption) — " BIMA grafting Predict higher rates of nosocomial infections than SIMA grafting in CABG population."
Hypothesis A.b (Assumption) — "BIMA grafting Predict higher rates of nosocomial infections rate than SIMA grafting in CABG-Diabetic population"

<u>The Odds of having Surgical Site Infections (SSIs) :</u>

In Total CABG Population — Hypothesis A assume that BIMA grafting predict higher rate of nosocomial infections in total CABG population. The bi-variate analysis reveal that BIMA grafting was associated with lower rate of surgical site infection in total CABG population. The p-value was less than alpha=0.05 and confidence interval included zero with odd ratio less than one. Therefore, we fail to accept the null hypothesis. However, the adjusted analysis on testing the hypothesis A assumption confirm that BIMA grafting has lower predictive effect, compared to SIMA grafting in the odds of getting surgical site infection in total CABG population (OR 0.958; 95% CI 0.95-0.95; p<.0001) (see Fig. 13).

Figure 13: Multivariate analysis of BIMA Grafting Effect on Surgical Site Infection (SSI) in total CABG population.

Logic Regression for Surgical Site Infection by BIMA in Total CABG Population

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.CABG_BIMA_AND_SIMA_ONLY	
Response Variable	SSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	243562
Number of Observations Used	127421
Sum of Weights Read	1203313
Sum of Weights Used	630118.2

Response Profile			
Ordered Value	SSI	Total Frequency	Total Weight
1	1	2061	10205.44
2	0	125360	619912.81

Probability modeled is SSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-6.1917	0.000233	704332489	<.0001
AGE		1	-0.00062	3.429E-6	33114.9592	<.0001
BIMA	1	1	-0.0213	0.000233	8308.9350	<.0001
FEMALE	1	1	-0.0311	0.000233	17814.7717	<.0001
RACE	2	1	-0.0375	0.000250	22426.1837	<.0001
RACE	3	1	0.1361	0.000252	292600.550	<.0001
RACE	4	1	-0.1614	0.000260	385285.114	<.0001
RACE	5	1	0.0313	0.000261	14381.1159	<.0001
RACE	6	1	0.0193	0.000256	5697.6613	<.0001
ELECTIVE	0	1	-1.4003	0.000233	36022639.7	<.0001
ATYPE	1	1	0.6905	0.000405	2911221.90	<.0001
ATYPE	2	1	0.8138	0.000439	3434351.78	<.0001
ATYPE	3	1	-1.9245	0.000376	26201694.0	<.0001
ATYPE	4	1	0.0124	0.0530	0.0546	0.8152
ATYPE	5	0	0	.	.	.
LOS		1	0.0455	9.854E-6	21343408.2	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.999	0.999	0.999
BIMA 1 vs 0	1.0000	0.958	0.957	0.959
FEMALE 1 vs 0	1.0000	0.940	0.939	0.940
RACE 2 vs 1	1.0000	0.952	0.950	0.953
RACE 3 vs 1	1.0000	1.132	1.130	1.134
RACE 4 vs 1	1.0000	0.841	0.839	0.842
RACE 5 vs 1	1.0000	1.019	1.018	1.021
RACE 6 vs 1	1.0000	1.007	1.006	1.009
ELECTIVE 0 vs 1	1.0000	0.061	0.061	0.061
ATYPE 1 vs 6	1.0000	1.327	1.196	1.472
ATYPE 2 vs 6	1.0000	1.501	1.353	1.665
ATYPE 3 vs 6	1.0000	0.097	0.087	0.108
ATYPE 4 vs 6	1.0000	0.673	0.547	0.829
LOS	1.0000	1.047	1.047	1.047
NCHRONIC 0 vs 26	1.0000	1.819	1.563	2.117

In Diabetic-CABG Population — In this hypothesis, we assume that using BIMA graft in diabetic patients increase the risk of nosocomial infections especially surgical site infection. The bi-variable analysis reveals that difference was non-significant in rate of surgical site infection (SSI) (1.04% vs. 1.26%; p=0.2491), comparing BIMA to SIMA grafting respectively. In Multivariable logistic regression analysis, the likelihood of getting SSI with BIMA grafting compared to SIMA grafting was significantly lower by 23.9% . BIMA graft had less predictive effect on surgical site infection (SSI) in

diabetic patients undergoing CABG surgery (OR: 0.761; 95% CI: 0.59-0.97; p=0.0296). (see Fig. 14).

Figure 14: Multivariate analysis of BIMA Grafting Effect on Surgical Site Infection (SSI) in Diabetic population.

Logic Regression for Surgical Site Infection by BIMA in Diabetic-CABG Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_SIMA_BIMA_ONLY	
Response Variable	SSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	107226
Number of Observations Used	55571
Sum of Weights Read	529636.6
Sum of Weights Used	274303.1

Response Profile			
Ordered Value	SSI	Total Frequency	Total Weight
1	1	659	3275.22
2	0	54912	271027.84

Probability modeled is SSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-14.5653	40.4657	0.1296	0.7189
AGE		1	-0.00574	0.00192	8.9345	0.0028
BIMA	1	1	-0.1366	0.0628	4.7325	0.0296
FEMALE	1	1	-0.0124	0.0204	0.3657	0.5453
RACE	2	1	-0.0747	0.0672	1.2364	0.2662
RACE	3	1	0.1734	0.0666	6.7755	0.0092
RACE	4	1	-0.4976	0.1441	11.9240	0.0006
RACE	5	1	0.4917	0.1324	13.8020	0.0002
RACE	6	1	-0.1343	0.0883	2.3121	0.1284
ELECTIVE	0	1	-8.3377	76.8183	0.0118	0.9136
ATYPE	1	1	5.2931	38.2945	0.0191	0.8901
ATYPE	2	1	5.7146	38.2945	0.0223	0.8814
ATYPE	3	1	10.8724	115.5	0.0089	0.9250

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.994	0.991	0.998
BIMA 1 vs 0	1.0000	0.761	0.595	0.973
FEMALE 1 vs 0	1.0000	0.976	0.900	1.057
RACE 2 vs 1	1.0000	0.890	0.781	1.015
RACE 3 vs 1	1.0000	1.141	1.003	1.299
RACE 4 vs 1	1.0000	0.583	0.418	0.814
RACE 5 vs 1	1.0000	1.569	1.159	2.124
RACE 6 vs 1	1.0000	0.839	0.694	1.015
ELECTIVE 0 vs 1	1.0000	<0.001	<0.001	>999.999
ATYPE 1 vs 5	1.0000	227.808	<0.001	>999.999
ATYPE 2 vs 5	1.0000	347.221	<0.001	>999.999
ATYPE 3 vs 5	1.0000	<0.001	<0.001	>999.999
LOS	1.0000	1.120	1.115	1.125

The Odds of having Urinary Tract Infections (UTIs):

In Total CABG Population — The alternative hypothesis assume that BIMA grafting predicts higher rate of UTI in overall sample. The adjusted analysis showed that BIMA grafting has border effect on the rate of the Urinary Tract infection (UTI) and increase the risk significantly by 6.9%, compared to SIMA grafting. Adjusted analysis was inconsistent with bivariate analysis. BIMA graft is significant predictor of UTI (OR

1.069; 95% CI 1.06-1.07; p<.0001). Therefore, we fail to accept the null hypothesis in multi-variate analysis that (see Fig.15)

Figure 15: Multivariate analysis of BIMA Effect on Urinary Tract Infections (UTI) in total CABG population.

Logic Regression for Urinary Tract Infection Rates by BIMA in Total CABG Pop

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.CABG_BIMA_AND_SIMA_ONLY	
Response Variable	UTI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge we
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	243562
Number of Observations Used	127421
Sum of Weights Read	1203313
Sum of Weights Used	630118.2

Response Profile			
Ordered Value	UTI	Total Frequency	Total Weight
1	1	7349	36285.30
2	0	120072	593832.94

Probability modeled is UTI=1.

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-10.2025	0.000137	5534472417	<.0001
AGE		1	0.0260	1.967E-6	174968329	<.0001
BIMA	1	1	0.0335	0.000137	59842.3254	<.0001
FEMALE	1	1	0.5908	0.000137	18557590.1	<.0001
RACE	2	1	0.0717	0.000147	239300.897	<.0001
RACE	3	1	0.0744	0.000149	249391.982	<.0001
RACE	4	1	-0.1684	0.000154	1200866.29	<.0001
RACE	5	1	0.00195	0.000154	160.5968	<.0001
RACE	6	1	0.0533	0.000151	123825.352	<.0001
ELECTIVE	0	1	-0.6284	0.000137	20994922.3	<.0001
ATYPE	1	1	0.1893	0.000228	688535.695	<.0001
ATYPE	2	1	0.0796	0.000257	95557.6420	<.0001
ATYPE	3	1	-1.4270	0.000231	38310080.2	<.0001
ATYPE	4	1	2.1625	0.0138	24383.6529	<.0001
ATYPE	5	1	0.8867	0.00479	34313.8263	<.0001
LOS		1	0.0251	7.845E-6	10218384.1	<.0001

Odds Ratio Estimates and Wald Confidence Intervals

Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.026	1.026	1.026
BIMA 1 vs 0	1.0000	1.069	1.069	1.070
FEMALE 1 vs 0	1.0000	3.259	3.258	3.261
RACE 2 vs 1	1.0000	1.110	1.109	1.111
RACE 3 vs 1	1.0000	1.113	1.112	1.114
RACE 4 vs 1	1.0000	0.873	0.873	0.874
RACE 5 vs 1	1.0000	1.036	1.035	1.036
RACE 6 vs 1	1.0000	1.090	1.089	1.091
ELECTIVE 0 vs 1	1.0000	0.285	0.284	0.285
ATYPE 1 vs 6	1.0000	8.008	7.781	8.241
ATYPE 2 vs 6	1.0000	7.175	6.972	7.385
ATYPE 3 vs 6	1.0000	1.591	1.546	1.637
ATYPE 4 vs 6	1.0000	57.600	54.513	60.863

In Diabetic-CABG Population — The alternative hypothesis here assume that BIMA grafting in diabetic patient predicts higher rate of UTI. The unadjusted analysis reveal that in diabetic patients undergoing BIMA grafting, prevalence of urinary tract

infection was significantly lower compared to diabetic patients with SIMA grafting (4.19% vs. 5.52%; p=0.0005). After adjustment for cofounders, multivariate analysis showed no significance difference (OR 1.066; 95% CI: 0.95-1.18; p=0.2486) in comparing the effect of BIMA to SIMA grafting in diabetic patients. Therefore, we choice to accept the null hypothesis. (see Fig. 16).

Figure 16: Multivariate analysis of BIMA Effect on Urinary Tract Infections (UTI) in Diabetic population.

Logic Regression for Urinary Tract Infection Rates by BIMA in Diabetic-CABG Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_SIMA_BIMA_ONLY	
Response Variable	UTI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	107226
Number of Observations Used	55571
Sum of Weights Read	529636.6
Sum of Weights Used	274303.1

Response Profile			
Ordered Value	UTI	Total Frequency	Total Weight
1	1	3113	15345.99
2	0	52458	258957.07

Probability modeled is UTI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-8.2379	6938.5	0.0000	0.9991
AGE		1	0.0233	0.000928	629.8423	<.0001
BIMA	1	1	0.0321	0.0279	1.3309	0.2486
FEMALE	1	1	0.6620	0.00913	5253.0563	<.0001
RACE	2	1	0.0612	0.0312	3.8466	0.0498
RACE	3	1	0.1194	0.0329	13.1583	0.0003
RACE	4	1	-0.1236	0.0594	4.3320	0.0374
RACE	5	1	-0.1677	0.0835	4.0372	0.0445
RACE	6	1	0.0918	0.0406	5.1039	0.0239
ELECTIVE	0	1	-1.5834	3.9584	0.1600	0.6892
ATYPE	1	1	0.8258	1.9771	0.1744	0.6762
ATYPE	2	1	0.6928	1.9771	0.1228	0.7260
ATYPE	3	1	-2.7025	5.9426	0.2068	0.6493

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.024	1.022	1.025
BIMA 1 vs 0	1.0000	1.066	0.956	1.189
FEMALE 1 vs 0	1.0000	3.758	3.626	3.895
RACE 2 vs 1	1.0000	1.043	0.986	1.104
RACE 3 vs 1	1.0000	1.106	1.039	1.177
RACE 4 vs 1	1.0000	0.867	0.758	0.992
RACE 5 vs 1	1.0000	0.830	0.683	1.008
RACE 6 vs 1	1.0000	1.076	0.988	1.170
ELECTIVE 0 vs 1	1.0000	0.042	<0.001	>999.999
ATYPE 1 vs 5	1.0000	0.699	0.338	1.444
ATYPE 2 vs 5	1.0000	0.612	0.296	1.264
ATYPE 3 vs 5	1.0000	0.021	<0.001	>999.999
LOS	1.0000	1.061	1.058	1.064
NCHRONIC 1 vs 21	1.0000	42.592	0.068	>999.999

<u>Odds of having Blood Stream Infections (BSIs) :</u>

In Total CABG Population — The adjusted results showed that BIMA was a strong predictor of BSI, compared to SIMA grafting method in overall CABG population. Bloodstream infection or sepsis was significantly higher by 46.7% with BIMA grafting compared to SIMA grafting. The risk ratio was (OR 1.467; 95% CI 1.34-1.60; p<.0001) (see Fig. 17). The null hypothesis was rejected. This result was not consistent with the preliminary result in the bivariate analysis that BIMA increases the risk of BSI in the alternative hypothesis (2.39% vs. 2.84%; p=0.0071).

Figure 17: Multivariate analysis of BIMA Effect on Blood Stream Infection (BSI) in Total CABG Population

Logic Regression for Blood-Stream Infection Rates by BIMA in Total CABG Population

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.CABG_BIMA_AND_SIMA_ONLY	
Response Variable	BSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	243562
Number of Observations Used	127421
Sum of Weights Read	1203313
Sum of Weights Used	630118.2

Response Profile			
Ordered Value	BSI	Total Frequency	Total Weight
1	1	3791	18686.21
2	0	123630	611432.04

Probability modeled is BSI=1.

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	94004.2	147.9	403804.629	<.0001
AGE		1	-0.00864	0.000831	108.0064	<.0001
BIMA	1	1	0.1917	0.0220	75.8718	<.0001
FEMALE	1	1	-0.0679	0.00951	50.9804	<.0001
RACE	2	1	0.1147	0.0315	13.2555	0.0003
RACE	3	1	-0.00913	0.0342	0.0711	0.7897
RACE	4	1	0.0470	0.0532	0.7819	0.3766
RACE	5	1	-0.2739	0.0853	10.3022	0.0013
RACE	6	1	0.1946	0.0383	25.8036	<.0001
ELECTIVE	0	1	4.8671	37.6708	0.0167	0.8972
ATYPE	1	1	0.3926	0.3919	1.0034	0.3165
ATYPE	2	1	0.4705	0.3920	1.4407	0.2300
ATYPE	3	1	10.1716	75.3324	0.0182	0.8926

Odds Ratio Estimates and Wald Confidence Intervals

Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.991	0.990	0.993
BIMA 1 vs 0	1.0000	1.467	1.346	1.600
FEMALE 1 vs 0	1.0000	0.873	0.841	0.906
RACE 2 vs 1	1.0000	1.207	1.138	1.279
RACE 3 vs 1	1.0000	1.066	0.997	1.140
RACE 4 vs 1	1.0000	1.128	1.002	1.269
RACE 5 vs 1	1.0000	0.818	0.670	0.998
RACE 6 vs 1	1.0000	1.307	1.209	1.414
ELECTIVE 0 vs 1	1.0000	>999.999	<0.001	>999.999
ATYPE 1 vs 6	1.0000	347.080	<0.001	>999.999
ATYPE 2 vs 6	1.0000	375.201	<0.001	>999.999
ATYPE 3 vs 6	1.0000	>999.999	<0.001	>999.999
ATYPE 4 vs 6	1.0000	0.886	<0.001	>999.999
LOS	1.0000	1.037	1.036	1.039
NCHRONIC 0 vs 26	1.0000	28.243	<0.001	>999.999

In Diabetic-CABG Population — Here the alternative hypothesis assume that BIMA grafting predict higher rate of bloodstream infection (BSI) in diabetic population. The adjusted analysis showed that BIMA grafting had increased the risk of BSI by 44.6% in diabetic patients. BIMA is strong predictor of BSI in diabetics (OR: 1.446 95% CI: 1.22-1.71; p<.0001) and therefore we choice to reject the null hypothesis. (see Fig. 18).

Figure 18: Multivariate analysis of BIMA Effect on Blood Stream Infection (BSI) in Diabetic population.

Logic Regression for Blood-Stream Infection Rates by BIMA in Diabetic-CABG Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_SIMA_BIMA_ONLY	
Response Variable	BSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	107226
Number of Observations Used	55571
Sum of Weights Read	529636.6
Sum of Weights Used	274303.1

Response Profile			
Ordered Value	BSI	Total Frequency	Total Weight
1	1	912	4496.27
2	0	54659	269806.79

Probability modeled is BSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-8.0622	59.2578	0.0185	0.8918
AGE		1	-0.0131	0.00161	66.6211	<.0001
BIMA	1	1	0.1845	0.0428	18.5457	<.0001
FEMALE	1	1	-0.0763	0.0178	18.2927	<.0001
RACE	2	1	0.1435	0.0552	6.7574	0.0093
RACE	3	1	0.0676	0.0581	1.3509	0.2451
RACE	4	1	-0.0883	0.0965	0.8378	0.3600
RACE	5	1	-0.3461	0.1575	4.8319	0.0279
RACE	6	1	0.3053	0.0641	22.6746	<.0001
ELECTIVE	0	1	-7.3320	36.4891	0.0404	0.8407
ATYPE	1	1	5.0439	17.9329	0.0791	0.7785
ATYPE	2	1	5.1061	17.9329	0.0811	0.7758
ATYPE	3	1	-9.7355	55.4501	0.0308	0.8606

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.987	0.984	0.990
BIMA 1 vs 0	1.0000	1.446	1.223	1.711
FEMALE 1 vs 0	1.0000	0.858	0.800	0.921
RACE 2 vs 1	1.0000	1.253	1.132	1.386
RACE 3 vs 1	1.0000	1.161	1.039	1.297
RACE 4 vs 1	1.0000	0.994	0.801	1.233
RACE 5 vs 1	1.0000	0.768	0.531	1.110
RACE 6 vs 1	1.0000	1.473	1.296	1.674
ELECTIVE 0 vs 1	1.0000	<0.001	<0.001	>999.999
ATYPE 1 vs 5	1.0000	234.731	<0.001	>999.999
ATYPE 2 vs 5	1.0000	249.807	<0.001	>999.999
ATYPE 3 vs 5	1.0000	<0.001	<0.001	>999.999
LOS	1.0000	1.054	1.050	1.058
NCHRONIC 1 vs 21	1.0000	0.964	<0.001	>999.999

<u>The Odds of having Pneumonia (PN):</u>

In Total CABG Population — The odds of pneumonia were slightly higher with BIMA grafting in overall CABG population, compared to SIMA grafting (OR: 1.061; 95% CI: 1.01-1.11; p=0.0114). BIMA grafting increase risk of pneumonia by 6.1% compared to SIMA in overall CABG population (see Fig. 19). The adjusted and unadjusted analysis were consistent and met our expectation in the alternative hypothesis.

Figure 19: Multivariate analysis of BIMA Effect on Pneumonia (PN) in Overall CABG population.

Logic Regression for Pneumonia Rates by BIMA in Total CABG Population

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.CABG_BIMA_AND_SIMA_ONLY	
Response Variable	PN	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	243562
Number of Observations Used	127421
Sum of Weights Read	1203313
Sum of Weights Used	630118.2

Response Profile			
Ordered Value	PN	Total Frequency	Total Weight
1	1	96423	477617.75
2	0	30998	152500.49

Probability modeled is PN=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	7.6408	34.4862	0.0491	0.8247
AGE		1	-0.00242	0.000405	35.5357	<.0001
BIMA	1	1	0.0295	0.0117	6.4076	0.0114
FEMALE	1	1	0.00851	0.00447	3.6252	0.0569
RACE	2	1	-0.2106	0.0157	179.1508	<.0001
RACE	3	1	0.0365	0.0172	4.4893	0.0341
RACE	4	1	0.0683	0.0292	5.4664	0.0194
RACE	5	1	0.1279	0.0369	12.0004	0.0005
RACE	6	1	0.0896	0.0206	18.8375	<.0001
ELECTIVE	0	1	-0.8447	0.6521	1.6777	0.1952
ATYPE	1	1	0.7421	0.1876	15.6512	<.0001
ATYPE	2	1	0.7153	0.1876	14.5364	0.0001
ATYPE	3	1	-1.1621	1.1768	0.9751	0.3234
ATYPE	4	1	-0.2774	0.6607	0.1763	0.6746

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.998	0.997	0.998
BIMA 1 vs 0	1.0000	1.061	1.013	1.110
FEMALE 1 vs 0	1.0000	1.017	0.999	1.035
RACE 2 vs 1	1.0000	0.906	0.879	0.933
RACE 3 vs 1	1.0000	1.160	1.121	1.200
RACE 4 vs 1	1.0000	1.197	1.121	1.279
RACE 5 vs 1	1.0000	1.271	1.167	1.384
RACE 6 vs 1	1.0000	1.223	1.171	1.277
ELECTIVE 0 vs 1	1.0000	0.185	0.014	2.380
ATYPE 1 vs 6	1.0000	2.138	0.599	7.632
ATYPE 2 vs 6	1.0000	2.081	0.583	7.430
ATYPE 3 vs 6	1.0000	0.318	0.011	9.306
ATYPE 4 vs 6	1.0000	0.771	0.130	4.565
LOS	1.0000	0.998	0.996	0.999

In Diabetic-CABG Population — The adjusted analysis showed that BIMA grafting was not a predictor of pneumonia in diabetic population undergoing CABG

surgery (OR: 0.978; 95% CI: 0.91-1.04; p=0.5238). The null hypothesis was accepted that is no difference between the effect of BIMA compared to SIMA grafting on the rate of pneumonia in diabetic patients. (see Fig. 20).

Figure 20: Multivariate analysis of BIMA Effect on Pneumonia (PN) in Diabetic population.

Logic Regression for Pneumonia Rates by BIMA in Diabetic-CABG Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_CABG_ONLY	
Response Variable	PN	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	122642
Number of Observations Used	63532
Sum of Weights Read	605630.9
Sum of Weights Used	313522.4

Response Profile			
Ordered Value	PN	Total Frequency	Total Weight
1	1	44122	218184.94
2	0	19410	95337.49

Probability modeled is PN=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	1.0016	38.4181	0.0007	0.9792
AGE		1	0.000305	0.000548	0.3094	0.5780
BIMA	1	1	-0.0110	0.0173	0.4065	0.5238
FEMALE	1	1	0.00578	0.00582	0.9849	0.3210
RACE	2	1	-0.2338	0.0197	141.0763	<.0001
RACE	3	1	0.0522	0.0209	6.2094	0.0127
RACE	4	1	0.1061	0.0361	8.6433	0.0033
RACE	5	1	0.0615	0.0457	1.8152	0.1779
RACE	6	1	0.1009	0.0256	15.5063	<.0001
ELECTIVE	0	1	-1.2458	1.3048	0.9116	0.3397
ATYPE	1	1	0.9774	0.6483	2.2729	0.1317
ATYPE	2	1	0.9287	0.6483	2.0520	0.1520
ATYPE	3	1	-1.7494	1.9669	0.7911	0.3738

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.000	0.999	1.001
BIMA 1 vs 0	1.0000	0.978	0.914	1.047
FEMALE 1 vs 0	1.0000	1.012	0.989	1.035
RACE 2 vs 1	1.0000	0.864	0.832	0.897
RACE 3 vs 1	1.0000	1.149	1.103	1.198
RACE 4 vs 1	1.0000	1.213	1.118	1.317
RACE 5 vs 1	1.0000	1.160	1.044	1.290
RACE 6 vs 1	1.0000	1.207	1.143	1.274
ELECTIVE 0 vs 1	1.0000	0.083	<0.001	13.778
ATYPE 1 vs 5	1.0000	3.108	1.744	5.541
ATYPE 2 vs 5	1.0000	2.961	1.661	5.277
ATYPE 3 vs 5	1.0000	0.203	0.001	37.291
LOS	1.0000	0.995	0.993	0.997

4.6.2 The effect of Diabetes Mellitus (DM):

Hypothesis B (Assumption) — " Diabetic patients have significantly higher rate of nosocomial infections than non-diabetic patients. (in total CABG, with SIMA only, and with BIMA only)"

Odds of having Surgical Site Infections (SSIs):

In Total CABG Population — The hypothesis assumes that patients with diabetes diagnosis have higher odds of SSI, compared to non-diabetic patients. After adjustment for covariates variable in the multiple logistic regression, the null hypothesis was rejected. However, result did not meet the expectation. Diabetic patients were less likely to get surgical site infection (SSIs) as compared to overall cohort (non-diabetic patients). The likelihood of SSIs was significantly lower in diabetic patients by 55.1% with confidence interval less than one (OR 0.449; 95% CI: 0.41-0.48; p<.0001). The result was consistent in both bi-variate and Multivariate logistic regression analyses, which confirms that diabetes has lower predictive effect on surgical site infection (SSI) in CABG as compared to those without diabetes. (see Fig. 21).

Figure 21: Multivariate analysis of Diabetes Effect on Surgical Site Infection (SSI) Overall CABG population.

Logic Regression for Surgical Site Infection by Presence of Diabetes Miletus (DM) in Total CABG Population

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.CABG_2007_2012_CORE_SEVERITY	
Response Variable	SSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	286487
Number of Observations Used	149715
Sum of Weights Read	1414776
Sum of Weights Used	740125.7

Response Profile			
Ordered Value	SSI	Total Frequency	Total Weight
1	1	2700	13354.30
2	0	147015	726771.41

Probability modeled is SSI=1.

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-1.4758	169.8	0.0001	0.9931
AGE		1	-0.00284	0.000901	9.9446	0.0016
Diabetes	1	1	-0.4008	0.0171	547.2814	<.0001
FEMALE	1	1	-0.0397	0.0103	14.8827	0.0001
RACE	2	1	-0.0214	0.0373	0.3287	0.5664
RACE	3	1	0.2497	0.0382	42.6252	<.0001
RACE	4	1	-0.3322	0.0752	19.4935	<.0001
RACE	5	1	-0.0469	0.0918	0.2618	0.6089
RACE	6	1	0.0634	0.0466	1.8527	0.1735
ELECTIVE	0	1	-14.1272	169.2	0.0070	0.9334
ATYPE	1	1	6.9194	8.7345	0.6276	0.4282
ATYPE	2	1	7.0259	8.7345	0.6470	0.4212

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.997	0.995	0.999
Diabetes 1 vs 0	1.0000	0.449	0.419	0.480
FEMALE 1 vs 0	1.0000	0.924	0.887	0.962
RACE 2 vs 1	1.0000	0.897	0.837	0.961
RACE 3 vs 1	1.0000	1.176	1.095	1.263
RACE 4 vs 1	1.0000	0.657	0.554	0.780
RACE 5 vs 1	1.0000	0.874	0.707	1.081
RACE 6 vs 1	1.0000	0.976	0.887	1.074
ELECTIVE 0 vs 1	1.0000	<0.001	<0.001	>999.999
ATYPE 1 vs 6	1.0000	>999.999	<0.001	>999.999
ATYPE 2 vs 6	1.0000	>999.999	<0.001	>999.999
ATYPE 3 vs 6	1.0000	<0.001	<0.001	>999.999

In CABG-SIMA Graft Only — The same hypothesis was examined in patients with SIMA grafting only. The adjusted analysis showed same effect that diabetes had lower predictive effect on the rate of surgical site infection in SIMA population. Diabetes diagnosis has significantly decreased the likelihood of SSI by 33.7% in SIMA grafting sub-population (OR:0.663; 95% CI:0.66-0.66 ; p<.0001). (see Fig. 22).

Figure 22: Multivariate analysis of Diabetes Effect on Surgical Site Infection (SSI) in SIMA grafting population.

Logic Regression for Surgical Site Infection by Presence of Diabetes Miletus (DM) in SIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.SIMA_ONLY	
Response Variable	SSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	233339
Number of Observations Used	122673
Sum of Weights Read	1153117
Sum of Weights Used	606548.1

Response Profile			
Ordered Value	SSI	Total Frequency	Total Weight
1	1	1996	9890.85
2	0	120677	596657.22

Probability modeled is SSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-6.0838	0.000237	660085389	<.0001
AGE		1	-0.00075	3.473E-6	46209.9151	<.0001
Diabetes	1	1	-0.2058	0.000237	755519.511	<.0001
FEMALE	1	1	-0.0301	0.000237	16146.9402	<.0001
RACE	2	1	-0.0385	0.000254	23009.9335	<.0001
RACE	3	1	0.1171	0.000255	210861.108	<.0001
RACE	4	1	-0.1534	0.000263	339555.724	<.0001
RACE	5	1	0.0479	0.000264	32885.7076	<.0001
RACE	6	1	0.00297	0.000260	130.5854	<.0001
ELECTIVE	0	1	-0.9459	0.000237	15958277.5	<.0001
ATYPE	1	1	0.5105	0.000412	1537854.87	<.0001
ATYPE	2	1	0.6351	0.000447	2019395.37	<.0001
ATYPE	3	1	-1.1803	0.000380	9643310.37	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.999	0.999	0.999
Diabetes 1 vs 0	1.0000	0.663	0.662	0.663
FEMALE 1 vs 0	1.0000	0.942	0.941	0.942
RACE 2 vs 1	1.0000	0.940	0.938	0.941
RACE 3 vs 1	1.0000	1.098	1.096	1.099
RACE 4 vs 1	1.0000	0.838	0.836	0.839
RACE 5 vs 1	1.0000	1.024	1.023	1.026
RACE 6 vs 1	1.0000	0.979	0.978	0.981
ELECTIVE 0 vs 1	1.0000	0.151	0.151	0.151
ATYPE 1 vs 6	1.0000	0.902	0.815	0.999
ATYPE 2 vs 6	1.0000	1.022	0.924	1.131
ATYPE 3 vs 6	1.0000	0.166	0.150	0.184
ATYPE 4 vs 6	1.0000	0.498	0.409	0.605

In CABG-BIMA Graft Only — Here the alternative hypothesis assume that diabetic patients have higher odds of SSI if underwent CABG with BIMA grafting . Adjusted analysis revealed that the presence of diabetes diagnosis in BIMA grafting sub-population has 55.3% lower predictive effect. The null hypothesis was reject but, did not meet the expectation (OR:0.447; 95% CI:0.25-0.78; p=0.0047). (see Fig. 23).

Figure 23: Multivariate analysis of Diabetes Effect on Surgical Site Infection (SSI) in BIMA grafting population.

Logic Regression for Surgical Site Infection by Presence of Diabetes Miletus (DM) in BIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.BIMA_ONLY	
Response Variable	SSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	10223
Number of Observations Used	4748
Sum of Weights Read	50196.37
Sum of Weights Used	23570.16

Response Profile			
Ordered Value	SSI	Total Frequency	Total Weight
1	1	65	314.584
2	0	4683	23255.580

Probability modeled is SSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-12.4915	65723.7	0.0000	0.9998
AGE		1	0.00747	0.00625	1.4283	0.2320
Diabetes	1	1	-0.4025	0.1425	7.9819	0.0047
FEMALE	1	1	-0.1407	0.0903	2.4272	0.1192
RACE	2	1	1.0527	0.8592	1.5011	0.2205
RACE	3	1	2.3687	0.8528	7.7144	0.0055
RACE	4	1	-3.8250	2.1095	3.2878	0.0698
RACE	5	1	-2.0464	3.7055	0.3050	0.5808
RACE	6	1	1.6270	0.8546	3.6247	0.0569
ELECTIVE	0	1	-0.3804	3.1741	0.0144	0.9046
ATYPE	1	1	1.1433	6.3470	0.0324	0.8570
ATYPE	2	1	1.3087	6.3471	0.0425	0.8366

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.007	0.995	1.020
Diabetes 1 vs 0	1.0000	0.447	0.256	0.782
FEMALE 1 vs 0	1.0000	0.755	0.530	1.075
RACE 2 vs 1	1.0000	1.258	0.776	2.039
RACE 3 vs 1	1.0000	4.691	3.150	6.988
RACE 4 vs 1	1.0000	0.010	<0.001	1.001
RACE 5 vs 1	1.0000	0.057	<0.001	328.991
RACE 6 vs 1	1.0000	2.234	1.425	3.504
ELECTIVE 0 vs 1	1.0000	0.467	<0.001	>999.999
ATYPE 1 vs 5	1.0000	36.428	<0.001	>999.999
ATYPE 2 vs 5	1.0000	42.978	<0.001	>999.999
LOS	1.0000	1.043	1.031	1.054

The Odds of having Urinary Tract Infections (UTIs):

In Total CABG Population — In overall sample of CABG, urinary tract infection (UTI) was 31.3% lower for diabetic patient compared to non-diabetics. The null hypothesis was rejected. Result did not meet the alterative hypothesis assumption. For CABG patients with diabetes, the odds of contracting UTI was significantly lower (OR 0.687; 95% CI: 0.68-0.68; p<.0001), compared to non-diabetics. (see Fig.24).

Figure 24: Multivariate analysis of Diabetes Effect on Urinary Tract Infections (UTI) in Overall CABG population.

Logic Regression for Urinary Tract Infection Rates by Presence of Diabetes Miletus (DM) in Total CABG Population

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.CABG_2007_2012_CORE_SEVERITY	
Response Variable	UTI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	286487
Number of Observations Used	149715
Sum of Weights Read	1414776
Sum of Weights Used	740125.7

Response Profile			
Ordered Value	UTI	Total Frequency	Total Weight
1	1	9024	44565.10
2	0	140691	695560.62

Probability modeled is UTI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-8.6515	0.000124	4869734697	<.0001
AGE		1	0.0266	1.764E-6	227544910	<.0001
Diabetes	1	1	-0.1878	0.000124	2294203.09	<.0001
FEMALE	1	1	0.5704	0.000124	21169276.9	<.0001
RACE	2	1	0.0596	0.000132	202707.564	<.0001
RACE	3	1	0.0813	0.000135	365643.484	<.0001
RACE	4	1	-0.1874	0.000139	1825595.61	<.0001
RACE	5	1	-0.0140	0.000139	10092.2894	<.0001
RACE	6	1	0.0990	0.000137	525728.476	<.0001
ELECTIVE	0	1	1.4894	0.000124	144322908	<.0001
ATYPE	1	1	-0.4324	0.000207	4365365.49	<.0001
ATYPE	2	1	-0.5632	0.000235	5746690.08	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.027	1.027	1.027
Diabetes 1 vs 0	1.0000	0.687	0.687	0.687
FEMALE 1 vs 0	1.0000	3.129	3.128	3.131
RACE 2 vs 1	1.0000	1.103	1.102	1.104
RACE 3 vs 1	1.0000	1.127	1.127	1.128
RACE 4 vs 1	1.0000	0.862	0.861	0.862
RACE 5 vs 1	1.0000	1.025	1.024	1.026
RACE 6 vs 1	1.0000	1.148	1.147	1.148
ELECTIVE 0 vs 1	1.0000	19.663	19.654	19.673
ATYPE 1 vs 6	1.0000	7.957	7.763	8.155
ATYPE 2 vs 6	1.0000	6.981	6.811	7.156
ATYPE 3 vs 6	1.0000	106.029	103.445	108.678
ATYPE 4 vs 6	1.0000	47.045	44.781	49.423
LOS	1.0000	1.023	1.023	1.023
NCHRONIC 0 vs 26	1.0000	<0.001	<0.001	>999.999

In CABG-SIMA Graft Only — For diabetic patients, the risk of UTI was 31% significantly lower compared to non-diabetics. The odds of contracting UTI was (OR: 0.690; 95% CI: 0.69-0.69; p<.0001) (see fig.25). The null hypothesis was rejected. However, The adjusted analysis results did not meet our expectation in the alternative hypothesis. It was also consistent with preliminary bivariate analysis that diabetics had lower rate of UTI compared to non-diabetic (5.52% vs. 5.82%; p=0.0017).

Figure 25: Multivariate analysis of Diabetes Effect on Urinary Tract Infection (UTI) in SIMA grafting population.

Logic Regression for Urinary Tract Infection Rates by Presence of Diabetes Miletus (DM) in SIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.SIMA_ONLY	
Response Variable	UTI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	233339
Number of Observations Used	122673
Sum of Weights Read	1153117
Sum of Weights Used	606548.1

Response Profile			
Ordered Value	UTI	Total Frequency	Total Weight
1	1	7144	35272.93
2	0	115529	571275.15

Probability modeled is UTI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-11.5386	0.000140	6828106513	<.0001
AGE		1	0.0263	1.999E-6	173348153	<.0001
Diabetes	1	1	-0.1856	0.000140	1766914.63	<.0001
FEMALE	1	1	0.5958	0.000140	18205916.2	<.0001
RACE	2	1	0.0513	0.000149	118265.393	<.0001
RACE	3	1	0.0682	0.000152	202574.971	<.0001
RACE	4	1	-0.1585	0.000156	1027443.42	<.0001
RACE	5	1	0.00940	0.000157	3592.7052	<.0001
RACE	6	1	0.0606	0.000154	154613.565	<.0001
ELECTIVE	0	1	1.7127	0.000140	150437614	<.0001
ATYPE	1	1	-0.5682	0.000232	6003654.44	<.0001
ATYPE	2	1	-0.6777	0.000262	6678142.50	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.027	1.027	1.027
Diabetes 1 vs 0	1.0000	0.690	0.690	0.690
FEMALE 1 vs 0	1.0000	3.292	3.291	3.294
RACE 2 vs 1	1.0000	1.086	1.085	1.087
RACE 3 vs 1	1.0000	1.104	1.103	1.105
RACE 4 vs 1	1.0000	0.880	0.880	0.881
RACE 5 vs 1	1.0000	1.041	1.040	1.042
RACE 6 vs 1	1.0000	1.096	1.095	1.097
ELECTIVE 0 vs 1	1.0000	30.735	30.718	30.752
ATYPE 1 vs 6	1.0000	9.195	8.953	9.443
ATYPE 2 vs 6	1.0000	8.241	8.025	8.464
ATYPE 3 vs 6	1.0000	197.721	192.527	203.055
ATYPE 4 vs 6	1.0000	75.147	71.254	79.253

In CABG-BIMA Graft Only — The alternative hypothesis assume that diabetes predicts higher rate of UTI in BIMA grafting sub-population. The unadjusted analysis showed higher trend in the rate of UTI for diabetic patients compared to non-diabetics (6.40% vs. 3.88%; p=0.0122), respectively. After adjustment, the multivariable logistic regression results had confirmed that diabetes was a strong predictor of UTI in BIMA grafting sub-population (OR: 1.217; 95% CI: 1.21-1.22; p<.0001) (see Fig.26) . Presence of diabetes diagnosis has increased odds of UTI by 21.7% in BIMA grafting sub-population.

Figure 26: Multivariate analysis of Diabetes Effect on Urinary Tract Infection (UTI) in BIMA grafting population.

Logic Regression for Urinary Tract Infection Rates by Presence of Diabetes Miletus (DM) in BIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.BIMA_ONLY	
Response Variable	UTI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	10223
Number of Observations Used	4748
Sum of Weights Read	50196.37
Sum of Weights Used	23570.16

Response Profile			
Ordered Value	UTI	Total Frequency	Total Weight
1	1	205	1012.371
2	0	4543	22557.793

Probability modeled is UTI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-3.5974	0.000805	19968735.5	<.0001
AGE		1	0.0135	0.000012	1170287.79	<.0001
Diabetes	1	1	0.0982	0.000805	14870.7783	<.0001
FEMALE	1	1	0.7652	0.000805	903554.230	<.0001
RACE	2	1	0.5183	0.000862	361890.900	<.0001
RACE	3	1	0.1842	0.000898	42135.0367	<.0001
RACE	4	1	-0.2452	0.000922	70777.7875	<.0001
RACE	5	1	-0.3843	0.000926	172179.227	<.0001
RACE	6	1	0.0319	0.000893	1278.2834	<.0001
ELECTIVE	0	1	0.8695	0.000805	1166700.43	<.0001
ATYPE	1	1	-1.4572	0.00141	1064835.20	<.0001
ATYPE	2	1	-1.4425	0.00144	1006214.47	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.014	1.014	1.014
Diabetes 1 vs 0	1.0000	1.217	1.213	1.221
FEMALE 1 vs 0	1.0000	4.620	4.606	4.635
RACE 2 vs 1	1.0000	1.865	1.856	1.874
RACE 3 vs 1	1.0000	1.335	1.329	1.342
RACE 4 vs 1	1.0000	0.869	0.865	0.874
RACE 5 vs 1	1.0000	0.756	0.752	0.760
RACE 6 vs 1	1.0000	1.147	1.141	1.152
ELECTIVE 0 vs 1	1.0000	5.692	5.674	5.710
ATYPE 1 vs 5	1.0000	0.013	0.013	0.013
ATYPE 2 vs 5	1.0000	0.013	0.013	0.013
LOS	1.0000	1.070	1.070	1.070

The Odds of having Blood Stream Infections (BSIs):

In Total CABG Population — The alternative hypothesis assume that diabetes predicts higher rate of bloodstream infection in overall CABG population. Adjusted analysis showed that the effect of diabetes on Blood Stream infection (BSI) had similar observed result as in previous type of infections, which indicates diabetic patients had lower odds of getting BSI by 58.8% than overall sample. The odds of BSI were significantly lower in diabetics (OR 0.412; 95% CI 0.39-0.43; p<.0001). The results did not meet our assumption in the alternative hypothesis. Diabetics had lower predictive

effect on the rate of BSI than others in overall CABG population. The preliminary unadjusted bi-variate analysis was consistent also with diabetes vs. non-diabetes in overall sample (1.35% vs. 2.1%; p<.0001) (see Fig. 27)

Figure 27: Multivariate analysis of Diabetes Effect on Blood Stream Infection (BSI) in Overall CABG population.

Logic Regression for Blood-Stream Infection Rates by Presence of Diabetes Miletus (DM) in Total CABG Population

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.CABG_2007_2012_CORE_SEVERITY	
Response Variable	BSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	286487
Number of Observations Used	149715
Sum of Weights Read	1414776
Sum of Weights Used	740125.7

Response Profile			
Ordered Value	BSI	Total Frequency	Total Weight
1	1	5173	25495.83
2	0	144542	714629.88

Probability modeled is BSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-6.5324	63.5718	0.0106	0.9182
AGE		1	-0.0107	0.000695	238.1557	<.0001
Diabetes	1	1	-0.4430	0.0131	1150.5098	<.0001
FEMALE	1	1	-0.0576	0.00801	51.5985	<.0001
RACE	2	1	0.0641	0.0275	5.4429	0.0196
RACE	3	1	0.0474	0.0299	2.5058	0.1134
RACE	4	1	0.0678	0.0472	2.0658	0.1506
RACE	5	1	-0.3604	0.0766	22.1393	<.0001
RACE	6	1	0.2502	0.0334	56.2229	<.0001
ELECTIVE	0	1	1.3875	59.1246	0.0006	0.9813
ATYPE	1	1	0.5180	0.3370	2.3622	0.1243
ATYPE	2	1	0.4997	0.3371	2.1978	0.1382
ATYPE	3	1	3.2418	118.2	0.0008	0.9781

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.989	0.988	0.991
Diabetes 1 vs 0	1.0000	0.412	0.392	0.434
FEMALE 1 vs 0	1.0000	0.891	0.864	0.920
RACE 2 vs 1	1.0000	1.142	1.087	1.201
RACE 3 vs 1	1.0000	1.124	1.061	1.190
RACE 4 vs 1	1.0000	1.147	1.033	1.273
RACE 5 vs 1	1.0000	0.747	0.625	0.893
RACE 6 vs 1	1.0000	1.376	1.286	1.472
ELECTIVE 0 vs 1	1.0000	16.038	<0.001	>999.999
ATYPE 1 vs 6	1.0000	>999.999	<0.001	>999.999
ATYPE 2 vs 6	1.0000	>999.999	<0.001	>999.999
ATYPE 3 vs 6	1.0000	>999.999	<0.001	>999.999

In CABG-SIMA Graft Only — In SIMA sub-population, diabetes diagnosis had a lower predictive effect on the rate of blood stream infection (BSI) (OR: 0.476; 95% CI: 0.44 - 0.50; p<.0001 (see Fig. 28). Presences of diabetes diagnosis has decreased rate of BSI by 52.4% in SIMA sub-population, compared to those without diabetes. The result was consistent with bivariate analysis result which showed that the trend of BSI was

lower in diabetic patients compared to non-diabetic (1.54 VS. 3.87; p<.0001), respectively. The null hypothesis was rejected, but diabetes diagnosis effect was protective and against the expectation.

Figure 28: Multivariate analysis of Diabetes Effect on Blood Stream Infection (BSI) in SIMA population.

Logic Regression for Blood-Stream Infection Rates by Presence of Diabetes Miletus (DM) in SIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information

Data Set	SASUSER.SIMA_ONLY	
Response Variable	BSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	233339
Number of Observations Used	122673
Sum of Weights Read	1153117
Sum of Weights Used	606548.1

Response Profile

Ordered Value	BSI	Total Frequency	Total Weight
1	1	3635	17927.42
2	0	119038	588620.66

Probability modeled is BSI=1.

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	76229.3	145.1	275879.173	<.0001
AGE		1	-0.00862	0.000854	101.8297	<.0001
Diabetes	1	1	-0.3711	0.0152	592.7476	<.0001
FEMALE	1	1	-0.0688	0.00970	50.2598	<.0001
RACE	2	1	0.1207	0.0325	13.8285	0.0002
RACE	3	1	0.000446	0.0352	0.0002	0.9899
RACE	4	1	0.0197	0.0552	0.1275	0.7211
RACE	5	1	-0.3010	0.0877	11.7780	0.0006
RACE	6	1	0.2157	0.0400	29.1199	<.0001
ELECTIVE	0	1	4.9538	37.3755	0.0176	0.8946
ATYPE	1	1	0.3350	0.3895	0.7399	0.3897
ATYPE	2	1	0.4256	0.3896	1.1935	0.2746
ATYPE	3	1	10.2926	74.7419	0.0190	0.8905
ATYPE	4	1	-5.5190	35.9965	0.0235	0.8781

Odds Ratio Estimates and Wald Confidence Intervals

Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.991	0.990	0.993
Diabetes 1 vs 0	1.0000	0.476	0.448	0.505
FEMALE 1 vs 0	1.0000	0.871	0.839	0.905
RACE 2 vs 1	1.0000	1.193	1.123	1.266
RACE 3 vs 1	1.0000	1.058	0.988	1.133
RACE 4 vs 1	1.0000	1.078	0.954	1.219
RACE 5 vs 1	1.0000	0.782	0.638	0.960
RACE 6 vs 1	1.0000	1.312	1.208	1.424
ELECTIVE 0 vs 1	1.0000	>999.999	<0.001	>999.999
ATYPE 1 vs 6	1.0000	354.034	<0.001	>999.999
ATYPE 2 vs 6	1.0000	387.588	<0.001	>999.999
ATYPE 3 vs 6	1.0000	>999.999	<0.001	>999.999

In CABG-BIMA GRAFT ONLY — The purpose of this sub-hypothesis is to examine the effect of diabetes diagnosis in BIMA grafting sub-population. After adjustment, multivariable logistic regression showed that diabetes predict lower risk of BSI by 73.7% compared to those without diabetes. The odds of BSI was significantly lower (OR: 0.263; 95% CI: 0.18 - 0.37; p<.0001) by diabetes diagnosis (see Fig. 29).

Same as other infections examined before, unadjusted analysis showed lower trend of BSI by diabetes versus non-diabetes (1.45% vs. 2.91%; p< .0001).

Figure 29: Multivariate analysis of Diabetes Effect on Blood Stream Infection (BSI) in BIMA population.

Logic Regression for Blood-Stream Infection Rates by Presence of Diabetes Miletus (DM) in BIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.BIMA_ONLY	
Response Variable	BSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	10223
Number of Observations Used	4748
Sum of Weights Read	50196.37
Sum of Weights Used	23570.16

Response Profile			
Ordered Value	BSI	Total Frequency	Total Weight
1	1	156	758.790
2	0	4592	22811.374

Probability modeled is BSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-12.5676	65.4656	0.0369	0.8478
AGE		1	-0.00672	0.00394	2.9050	0.0883
Diabetes	1	1	-0.6684	0.0930	51.6626	<.0001
FEMALE	1	1	-0.0976	0.0550	3.1413	0.0763
RACE	2	1	0.0279	0.1498	0.0346	0.8524
RACE	3	1	-0.1047	0.1756	0.3556	0.5509
RACE	4	1	0.3628	0.2430	2.2295	0.1354
RACE	5	1	-0.0681	0.4143	0.0270	0.8695
RACE	6	1	0.2389	0.1522	2.4625	0.1166
ELECTIVE	0	1	-1.4228	37.5058	0.0014	0.9697
ATYPE	1	1	2.8244	75.0116	0.0014	0.9700
ATYPE	2	1	2.6198	75.0116	0.0012	0.9721

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.993	0.986	1.001
Diabetes 1 vs 0	1.0000	0.263	0.182	0.378
FEMALE 1 vs 0	1.0000	0.823	0.663	1.021
RACE 2 vs 1	1.0000	1.624	1.221	2.158
RACE 3 vs 1	1.0000	1.422	0.993	2.037
RACE 4 vs 1	1.0000	2.270	1.324	3.889
RACE 5 vs 1	1.0000	1.475	0.561	3.876
RACE 6 vs 1	1.0000	2.005	1.492	2.694
ELECTIVE 0 vs 1	1.0000	0.058	<0.001	>999.999
ATYPE 1 vs 5	1.0000	>999.999	<0.001	>999.999
ATYPE 2 vs 5	1.0000	>999.999	<0.001	>999.999
LOS	1.0000	1.036	1.027	1.045
NCHRONIC 1 vs 19	1.0000	11.203	<0.001	>999.999

<u>The Odds of having Pneumonia (PN)</u>:

In Total CABG Population — Similar to the previous infections results, the odds of pneumonia was significantly lower in diabetic patients compared to non-diabetics by 55.1%. Diabetic patients were less likely to get pneumonia (OR 0.449; 95% CI 0.43 -

0.46; p<.0001) (see Fig. 30). The results did not meet our expectation in the alternative hypothesis that diabetes had higher predictive effect on pneumonia rates in overall CABG population.

Figure 30: Multivariate analysis of Diabetes Effect on Pneumonia (PN) in Overall CABG population.

Logic Regression for Pneumonia Rates by Presence of Diabetes Miletus (DM) in Total CABG Population

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.CABG_2007_2012_CORE_SEVERITY	
Response Variable	PN	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	286487
Number of Observations Used	149715
Sum of Weights Read	1414776
Sum of Weights Used	740125.7

Response Profile			
Ordered Value	PN	Total Frequency	Total Weight
1	1	111887	554049.32
2	0	37828	186076.40

Probability modeled is PN=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	6.0829	34.6815	0.0308	0.8608
AGE		1	-0.00260	0.000364	50.8795	<.0001
Diabetes	1	1	-0.3999	0.00652	3760.0289	<.0001
FEMALE	1	1	0.00628	0.00401	2.4467	0.1178
RACE	2	1	-0.1817	0.0144	159.9785	<.0001
RACE	3	1	0.0361	0.0158	5.2324	0.0222
RACE	4	1	0.0503	0.0269	3.5025	0.0613
RACE	5	1	0.1408	0.0340	17.1590	<.0001
RACE	6	1	0.0587	0.0188	9.7641	0.0018
ELECTIVE	0	1	-1.2924	0.6044	4.5716	0.0325
ATYPE	1	1	0.9159	0.1695	29.2004	<.0001
ATYPE	2	1	0.9215	0.1695	29.5450	<.0001
ATYPE	3	1	1.8090	1.0969	2.7198	0.0991

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.997	0.997	0.998
Diabetes 1 vs 0	1.0000	0.449	0.438	0.461
FEMALE 1 vs 0	1.0000	1.013	0.997	1.029
RACE 2 vs 1	1.0000	0.925	0.901	0.951
RACE 3 vs 1	1.0000	1.151	1.115	1.187
RACE 4 vs 1	1.0000	1.167	1.098	1.240
RACE 5 vs 1	1.0000	1.278	1.181	1.382
RACE 6 vs 1	1.0000	1.177	1.131	1.225
ELECTIVE 0 vs 1	1.0000	0.075	0.007	0.806
ATYPE 1 vs 6	1.0000	1.942	0.539	6.999
ATYPE 2 vs 6	1.0000	1.953	0.542	7.038
ATYPE 3 vs 6	1.0000	0.127	0.005	3.274
ATYPE 4 vs 6	1.0000	0.587	0.108	3.183

In CABG-SIMA GRAFT ONLY — In patient undergoing CABG with SIMA grafting, effect of diabetes diagnosis significantly predicted lower odds of pneumonia (PN) (OR: 0.457; 95% CI: 0.44 - 0.47; p<.0001). Diabetes has lower the risk of PN by 54.3% in SIMA grafting sub-population. Unadjusted analysis showed consistent result in

the testing this sub-hypothesis DM vs. non-DM (70.49% vs. 80.38% p<.0001). (see fig.31)

Figure 31: Multivariate analysis of Diabetes Effect on Pneumonia (PN) in SIMA population.

Logic Regression for Pneumonia Rates by Presence of Diabetes Miletus (DM) in SIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.SIMA_ONLY	
Response Variable	PN	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	233339
Number of Observations Used	122673
Sum of Weights Read	1153117
Sum of Weights Used	606548.1

Response Profile			
Ordered Value	PN	Total Frequency	Total Weight
1	1	92468	457948.79
2	0	30205	148599.29

Probability modeled is PN=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	7.9123	34.3622	0.0530	0.8179
AGE		1	-0.00253	0.000414	37.2422	<.0001
Diabetes	1	1	-0.3919	0.00734	2854.9200	<.0001
FEMALE	1	1	0.00703	0.00454	2.3996	0.1214
RACE	2	1	-0.2188	0.0160	186.9768	<.0001
RACE	3	1	0.0343	0.0175	3.8497	0.0498
RACE	4	1	0.0774	0.0297	6.8032	0.0091
RACE	5	1	0.1237	0.0374	10.9136	0.0010
RACE	6	1	0.0986	0.0212	21.7304	<.0001
ELECTIVE	0	1	-1.1775	0.6643	3.1417	0.0763
ATYPE	1	1	0.8677	0.1938	20.0442	<.0001
ATYPE	2	1	0.8398	0.1938	18.7718	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.997	0.997	0.998
Diabetes 1 vs 0	1.0000	0.457	0.444	0.470
FEMALE 1 vs 0	1.0000	1.014	0.996	1.032
RACE 2 vs 1	1.0000	0.902	0.875	0.929
RACE 3 vs 1	1.0000	1.161	1.122	1.202
RACE 4 vs 1	1.0000	1.212	1.134	1.297
RACE 5 vs 1	1.0000	1.270	1.164	1.385
RACE 6 vs 1	1.0000	1.238	1.184	1.295
ELECTIVE 0 vs 1	1.0000	0.095	0.007	1.283
ATYPE 1 vs 6	1.0000	2.109	0.590	7.539
ATYPE 2 vs 6	1.0000	2.051	0.574	7.332
ATYPE 3 vs 6	1.0000	0.161	0.005	4.880
ATYPE 4 vs 6	1.0000	0.784	0.132	4.663
LOS	1.0000	0.995	0.994	0.997

In CABG-BIMA Graft Only — the odds of pneumonia was 66.1% significantly lower by presence of diabetes diagnosis patients. Diabetes decrease likelihood of pneumonia (OR: 0.339; 95% CI: 0.28 - 0.40; p<.0001) (see Fig. 32). After adjustment also, results did not meet our expectation in the alternative hypothesis that diabetes had

higher predictive effect on pneumonia rates in BIMA grafting sub-population. The adjusted analysis revealed same conclusion about the rate of PN in BIMA sub-population comparing DM vs. NON-DM (76.82% vs. 87.09%; p<.0001).

Figure 32: Multivariate analysis of Diabetes Effect on Pneumonia (PN) in BIMA population.

Logic Regression for Pneumonia Rates by Presence of Diabetes Miletus (DM) in BIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.BIMA_ONLY	
Response Variable	PN	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	10223
Number of Observations Used	4748
Sum of Weights Read	50196.37
Sum of Weights Used	23570.16

Response Profile			
Ordered Value	PN	Total Frequency	Total Weight
1	1	3955	19668.961
2	0	793	3901.203

Probability modeled is PN=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	2.0084	51.8541	0.0015	0.9691
AGE		1	-0.00060	0.00232	0.0677	0.7948
Diabetes	1	1	-0.5402	0.0428	158.9074	<.0001
FEMALE	1	1	0.00617	0.0298	0.0427	0.8362
RACE	2	1	-0.2041	0.0961	4.5107	0.0337
RACE	3	1	-0.0113	0.1062	0.0114	0.9151
RACE	4	1	-0.0677	0.1764	0.1473	0.7011
RACE	5	1	-0.0859	0.2424	0.1256	0.7231
RACE	6	1	0.2910	0.1060	7.5394	0.0060
ELECTIVE	0	1	-1.9982	44.5039	0.0020	0.9642
ATYPE	1	1	4.0463	89.0078	0.0021	0.9637
ATYPE	2	1	4.0859	89.0078	0.0021	0.9634

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.999	0.995	1.004
Diabetes 1 vs 0	1.0000	0.339	0.287	0.402
FEMALE 1 vs 0	1.0000	1.012	0.901	1.138
RACE 2 vs 1	1.0000	0.754	0.632	0.901
RACE 3 vs 1	1.0000	0.915	0.740	1.130
RACE 4 vs 1	1.0000	0.864	0.581	1.287
RACE 5 vs 1	1.0000	0.849	0.484	1.490
RACE 6 vs 1	1.0000	1.237	1.002	1.528
ELECTIVE 0 vs 1	1.0000	0.018	<0.001	>999.999
ATYPE 1 vs 5	1.0000	>999.999	<0.001	>999.999
ATYPE 2 vs 5	1.0000	>999.999	<0.001	>999.999
LOS	1.0000	0.996	0.989	1.004

4.6.3 The effect of Uncontrolled Hyperglycemia:

Hypothesis C (Assumption) — "Diabetic Patients with Uncontrolled Hyperglycemia (HbA1C) have significantly higher rate of nosocomial infections than diabetic patients with controlled hyperglycemia. (in total CABG, with SIMA only, and with BIMA only)"

The Odds of having Surgical Site Infections (SSIs):

In Total CABG Population — Among diabetic patients those who had uncontrolled hyperglycemia (HbA1c) or uncontrolled diabetes were at higher risk of having surgical site infection compared to their counterpart the diabetic with controlled hyperglycemia (OR 1.038; 95% CI 1.03-1.04; p<.0001). The confidence interval does not include zero and difference in log-odd was increased by 3.8% with the presence of uncontrolled hyperglycemia diabetic population. There was slight increase but, this indicate that uncontrolled hyperglycemia is independent risk factor for surgical site infection in diabetic patients undergoing CABG surgery (see Fig. 33).

Figure 33: Multivariate analysis of Uncontrolled hyperglycemia (HbA1c) Effect on Surgical Site Infection (SSI) in overall CABG-Diabetic patients.

Logic Regression for Surgical Site Infection by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics Undergoing CABG surgery

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_CABG_ONLY	
Response Variable	SSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	122642
Number of Observations Used	63532
Sum of Weights Read	605630.9
Sum of Weights Used	313522.4

Response Profile			
Ordered Value	SSI	Total Frequency	Total Weight
1	1	812	4034.08
2	0	62720	309488.34

Probability modeled is SSI=1.

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-4.3458	0.000340	163760196	<.0001
AGE		1	-0.00012	5.072E-6	575.2124	<.0001
Uncontrolled_HbA1c	1	1	0.0188	0.000340	3056.5320	<.0001
FEMALE	1	1	0.0153	0.000340	2018.6261	<.0001
RACE	2	1	0.00846	0.000369	526.4594	<.0001
RACE	3	1	0.00989	0.000373	703.2665	<.0001
RACE	4	1	-0.00116	0.000387	8.9897	0.0027
RACE	5	1	0.00725	0.000389	346.3814	<.0001
RACE	6	1	-0.00282	0.000381	54.8757	<.0001
ELECTIVE	0	1	-0.00108	0.000340	10.1760	0.0014
ATYPE	1	1	-0.0550	0.000596	8525.0494	<.0001

Odds Ratio Estimates and Wald Confidence Intervals

Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.000	1.000	1.000
Uncontrolled_HbA1c 1 vs 0	1.0000	1.038	1.037	1.040
FEMALE 1 vs 0	1.0000	1.031	1.030	1.032
RACE 2 vs 1	1.0000	1.031	1.028	1.033
RACE 3 vs 1	1.0000	1.032	1.030	1.034
RACE 4 vs 1	1.0000	1.021	1.019	1.023
RACE 5 vs 1	1.0000	1.029	1.027	1.031
RACE 6 vs 1	1.0000	1.019	1.017	1.021
ELECTIVE 0 vs 1	1.0000	0.998	0.997	0.999
ATYPE 1 vs 5	1.0000	0.935	0.932	0.937
ATYPE 2 vs 5	1.0000	1.035	1.031	1.038
ATYPE 3 vs 5	1.0000	0.983	0.981	0.986
LOS	1.0000	1.039	1.039	1.039

In CABG-SIMA GRAFT ONLY — However, uncontrolled HbA1c in diabetic undergoing SIMA grafting was not a significant predictor of surgical site infection (SSI) (OR: 0.937; 95% CI: 0.84-1.03; p=0.2020) (see Fig. 34).The p >0.05 and the null hypothesis was accepted. This was inconsistent with the unadjusted result that showed diabetics with uncontrolled hyperglycemia in SIMA grafting sub-population had 1.5 fold increase in the rate of SSI, compared to their counterpart group with controlled hyperglycemia (1.81 vs. 1.16; p<.0001).

Figure 34: Multivariate analysis of Uncontrolled hyperglycemia (HbA1c) Effect on Surgical Site Infection (SSI) in Diabetics-SIMA grafting population.

Logic Regression for Surgical Site Infection by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics with SIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_SIMA_ONLY	
Response Variable	SSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	103577
Number of Observations Used	53866
Sum of Weights Read	511701
Sum of Weights Used	265861.4

Response Profile			
Ordered Value	SSI	Total Frequency	Total Weight
1	1	643	3197.36
2	0	53223	262664.08

Probability modeled is SSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-16.5267	146.2	0.0128	0.9100
AGE		1	-0.00637	0.00196	10.5212	0.0012
Uncontrolled_HbA1c	1	1	-0.0323	0.0253	1.6280	0.2020
FEMALE	1	1	-0.0145	0.0207	0.4915	0.4833
RACE	2	1	-0.0606	0.0679	0.7974	0.3719
RACE	3	1	0.1660	0.0676	6.0331	0.0140
RACE	4	1	-0.4447	0.1443	9.4974	0.0021
RACE	5	1	0.5072	0.1327	14.6090	0.0001
RACE	6	1	-0.2114	0.0924	5.2336	0.0222
ELECTIVE	0	1	-9.7984	126.3	0.0060	0.9382
ATYPE	1	1	6.2473	62.9820	0.0098	0.9210
ATYPE	2	1	6.7106	62.9820	0.0114	0.9151
ATYPE	3	1	-12.7944	189.9	0.0045	0.9463

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.994	0.990	0.997
Uncontrolled_HbA1c 1 vs 0	1.0000	0.937	0.849	1.035
FEMALE 1 vs 0	1.0000	0.971	0.896	1.054
RACE 2 vs 1	1.0000	0.901	0.790	1.029
RACE 3 vs 1	1.0000	1.130	0.991	1.289
RACE 4 vs 1	1.0000	0.614	0.440	0.857
RACE 5 vs 1	1.0000	1.590	1.174	2.154
RACE 6 vs 1	1.0000	0.775	0.634	0.947
ELECTIVE 0 vs 1	1.0000	<0.001	<0.001	>999.999
ATYPE 1 vs 5	1.0000	608.423	<0.001	>999.999
ATYPE 2 vs 5	1.0000	966.916	<0.001	>999.999
ATYPE 3 vs 5	1.0000	<0.001	<0.001	>999.999
LOS	1.0000	1.123	1.117	1.128

In CABG-BIMA Graft Only — Diabetes with uncontrolled hyperglycemia was a strong predictor of surgical site infection (SSI) (OR: 1.520; 95% CI: 1.50-1.53; p<.0001). Uncontrolled hyperglycemia had significantly increased the odds of SSI by 52% in BIMA grafting subpopulation. The adjusted results met our expectation in the alternative hypothesis (see Fig. 35).The unadjusted result was also consistent with SSI incidence, which was significantly higher in diabetics with uncontrolled hyperglycemia by 2.5 folds higher with presence of uncontrolled hyperglycemia (2.21 vs. 0.88; p=0.0090).

Figure 35: Multivariate analysis of Uncontrolled hyperglycemia (HbA1c) Effect on Surgical Site Infection (SSI) in Diabetics-BIMA grafting population.

Logic Regression for Surgical Site Infection by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics with BIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_BIMA_ONLY	
Response Variable	SSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	3649
Number of Observations Used	1705
Sum of Weights Read	17935.61
Sum of Weights Used	8441.62

Response Profile			
Ordered Value	SSI	Total Frequency	Total Weight
1	1	16	77.8563
2	0	1689	8363.7638

Probability modeled is SSI=1.

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiS
Intercept		1	-0.0976	0.00228	1841.5563	<.000
AGE		1	0.00150	0.000037	1693.7888	<.000
Uncontrolled_HbA1c	1	1	0.2094	0.00228	8469.0038	<.000
FEMALE	1	1	0.0247	0.00228	118.2496	<.000
RACE	2	1	-0.3365	0.00262	16547.8370	<.000
RACE	3	1	0.2531	0.00264	9165.3041	<.000
RACE	4	1	-0.4670	0.00277	28496.2891	<.000
RACE	5	1	-0.1225	0.00280	1918.7522	<.000
RACE	6	1	1.1169	0.00253	194612.689	<.000
ELECTIVE	0	1	0.1149	0.00228	2549.6056	<.000
ATYPE	1	1	0.7298	0.00361	40938.1742	<.000
ATYPE	2	1	0.0954	0.00469	413.9595	<.000

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.002	1.001	1.002
Uncontrolled_HbA1c 1 vs 0	1.0000	1.520	1.507	1.534
FEMALE 1 vs 0	1.0000	1.051	1.041	1.060
RACE 2 vs 1	1.0000	1.114	1.097	1.130
RACE 3 vs 1	1.0000	2.008	1.979	2.038
RACE 4 vs 1	1.0000	0.977	0.963	0.992
RACE 5 vs 1	1.0000	1.379	1.359	1.400
RACE 6 vs 1	1.0000	4.764	4.695	4.833
ELECTIVE 0 vs 1	1.0000	1.258	1.247	1.270
ATYPE 1 vs 5	1.0000	4.736	4.656	4.816
ATYPE 2 vs 5	1.0000	2.511	2.462	2.561
LOS	1.0000	1.025	1.024	1.025

The Odds of having Urinary Tract Infections (UTIs):

In Total CABG Population — Among Diabetic patients with uncontrolled hyperglycemia, the likelihood of having urinary tract infection was significantly higher. The likelihood estimate showed a positive regression coefficient with increase in log-odds by 0.72 unit. Which means that uncontrolled hyperglycemia had increased the odds of UTI by 20.8% in overall CABG population. The uncontrolled diabetes had higher odds of UTI (OR 1.208; 95% CI: 1.15-1.26; p<.0001) (see Fig. 36). This was also consistent with the unadjusted result that showed diabetics with uncontrolled hyperglycemia had 1.5 higher risk of UTI (7.77 vs. 5.17; p<.0001), compared to those with controlled hyperglycemia.

Figure 36: Multivariate analysis of Uncontrolled Hyperglycemia Effect on Urinary Tract Infections (UTI) in Overall Diabetic-CABG population.

Logic Regression for Urinary Tract Infection Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics Undergoing CABG surgery

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_CABG_ONLY	
Response Variable	UTI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	122642
Number of Observations Used	63532
Sum of Weights Read	605630.9
Sum of Weights Used	313522.4

Response Profile			
Ordered Value	UTI	Total Frequency	Total Weight
1	1	3611	17796.36
2	0	59921	295726.06

Probability modeled is UTI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-8.0747	10579.1	0.0000	0.9994
AGE		1	0.0239	0.000868	760.4076	<.0001
Uncontrolled_HbA1c	1	1	0.0945	0.0108	77.0701	<.0001
FEMALE	1	1	0.6425	0.00850	5719.1136	<.0001
RACE	2	1	0.0559	0.0297	3.5422	0.0598
RACE	3	1	0.1592	0.0310	26.3012	<.0001
RACE	4	1	-0.1599	0.0572	7.8302	0.0051
RACE	5	1	-0.2246	0.0810	7.6847	0.0056
RACE	6	1	0.1273	0.0384	10.9684	0.0009
ELECTIVE	0	1	-1.1581	3.5366	0.1072	0.7433
ATYPE	1	1	0.5667	1.7667	0.1029	0.7484
ATYPE	2	1	0.4313	1.7667	0.0596	0.8071

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.024	1.022	1.026
Uncontrolled_HbA1c 1 vs 0	1.0000	1.208	1.158	1.260
FEMALE 1 vs 0	1.0000	3.615	3.496	3.737
RACE 2 vs 1	1.0000	1.014	0.961	1.070
RACE 3 vs 1	1.0000	1.124	1.061	1.191
RACE 4 vs 1	1.0000	0.817	0.718	0.930
RACE 5 vs 1	1.0000	0.766	0.634	0.925
RACE 6 vs 1	1.0000	1.089	1.006	1.179
ELECTIVE 0 vs 1	1.0000	0.099	<0.001	>999.999
ATYPE 1 vs 5	1.0000	0.583	0.319	1.065
ATYPE 2 vs 5	1.0000	0.509	0.279	0.930
ATYPE 3 vs 5	1.0000	0.040	<0.001	>999.999
LOS	1.0000	1.061	1.059	1.064

In CABG-SIMA GRAFT ONLY — adjusted result showed that presence of Uncontrolled hyperglycemia in diabetics with SIMA grafting sub-population had significantly higher odds of UTI by 20.9%, compared to diabetic with controlled hyperglycemia (OR: 1.209; 95% CI: 1.15-1.26; p<.0001). the adjusted result met the expectation in the alternative hypothesis. Also the unadjusted result was consistent with this conclusion in comparing the rate of UTI between uncontrolled and controlled hyperglycemia in diabetic patient underwent CABG with SIMA grafting. The rate of UTI

was 1.5 times higher in diabetic with uncontrolled hyperglycemia relative to those with controlled. (see Fig. 37).

Figure 37: Multivariate analysis of Uncontrolled Hyperglycemia Effect on Urinary Tract Infections (UTI) in Diabetic-SIMA population.

Logic Regression for Urinary Tract Infection Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics with SIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_SIMA_ONLY	
Response Variable	UTI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	103577
Number of Observations Used	53866
Sum of Weights Read	511701
Sum of Weights Used	265861.4

Response Profile			
Ordered Value	UTI	Total Frequency	Total Weight
1	1	3036	14967.80
2	0	50830	250893.64

Probability modeled is UTI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-4.1129	86.5352	0.0023	0.9621
AGE		1	0.0259	0.000953	736.7416	<.0001
Uncontrolled_HbA1c	1	1	0.0948	0.0116	67.1511	<.0001
FEMALE	1	1	0.6660	0.00928	5155.1663	<.0001
RACE	2	1	0.0472	0.0317	2.2108	0.1370
RACE	3	1	0.1153	0.0334	11.9448	0.0005
RACE	4	1	-0.1130	0.0604	3.4952	0.0615
RACE	5	1	-0.1701	0.0841	4.0870	0.0432
RACE	6	1	0.0935	0.0414	5.0931	0.0240
ELECTIVE	0	1	-8.7801	1.2171	52.0368	<.0001
ATYPE	1	1	3.1680	0.5956	28.2918	<.0001
ATYPE	2	1	3.0412	0.5955	26.0800	<.0001
ATYPE	3	1	-14.7397	1.8562	63.0587	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.026	1.024	1.028
Uncontrolled_HbA1c 1 vs 0	1.0000	1.209	1.155	1.265
FEMALE 1 vs 0	1.0000	3.788	3.653	3.929
RACE 2 vs 1	1.0000	1.020	0.963	1.081
RACE 3 vs 1	1.0000	1.092	1.025	1.164
RACE 4 vs 1	1.0000	0.869	0.758	0.996
RACE 5 vs 1	1.0000	0.821	0.675	0.998
RACE 6 vs 1	1.0000	1.069	0.980	1.165
ELECTIVE 0 vs 1	1.0000	<0.001	<0.001	<0.001
ATYPE 1 vs 5	1.0000	0.005	0.002	0.013
ATYPE 2 vs 5	1.0000	0.004	0.002	0.011
ATYPE 3 vs 5	1.0000	<0.001	<0.001	<0.001
LOS	1.0000	1.062	1.059	1.065

In CABG-BIMA GRAFT ONLY — after adjustment, result showed that uncontrolled hyperglycemia had increased the risk of UTI by 104.9% in diabetics underwent CABG with BIMA grafting. The adjusted result met the expectation in the

alternative hypothesis and the unadjusted analysis was consistent (uncontrolled: 6.40% vs. controlled: 3.88% ;p=0.0122). (see Fig. 38).

Figure 38: Multivariate analysis of Uncontrolled Hyperglycemia Effect on Urinary Tract Infections (UTI) in Diabetic-BIMA population.

Logic Regression for Urinary Tract Infection Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics with BIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_BIMA_ONLY	
Response Variable	UTI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	3649
Number of Observations Used	1705
Sum of Weights Read	17935.61
Sum of Weights Used	8441.62

Response Profile			
Ordered Value	UTI	Total Frequency	Total Weight
1	1	77	378.1905
2	0	1628	8063.4295

Probability modeled is UTI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-25.0558	331776	0.0000	0.9999
AGE		1	0.0117	0.00629	3.4705	0.0625
Uncontrolled_HbA1c	1	1	0.3587	0.0878	16.6946	<.0001
FEMALE	1	1	0.5696	0.0637	80.0723	<.0001
RACE	2	1	1.7836	3.4449	0.2681	0.6046
RACE	3	1	1.5458	3.4468	0.2011	0.6538
RACE	4	1	0.4466	3.4637	0.0166	0.8974
RACE	5	1	-5.9036	17.2046	0.1177	0.7315
RACE	6	1	1.3537	3.4471	0.1542	0.6945
ELECTIVE	0	1	-6.3809	0.0812	6182.5150	<.0001
ATYPE	1	1	13.4295	0.1539	7611.9688	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	1.012	0.999	1.024
Uncontrolled_HbA1c 1 vs 0	1.0000	2.049	1.453	2.891
FEMALE 1 vs 0	1.0000	3.124	2.434	4.010
RACE 2 vs 1	1.0000	2.745	1.933	3.898
RACE 3 vs 1	1.0000	2.164	1.368	3.423
RACE 4 vs 1	1.0000	0.721	0.283	1.834
RACE 5 vs 1	1.0000	0.001	<0.001	>999.999
RACE 6 vs 1	1.0000	1.786	1.121	2.846
ELECTIVE 0 vs 1	1.0000	<0.001	<0.001	<0.001
ATYPE 1 vs 5	1.0000	>999.999	>999.999	>999.999
LOS	1.0000	1.051	1.029	1.072

The Odds of having Blood Stream Infections (BSIs):

In Total CABG Population — In diabetic patients population, the odds of BSIs were significantly lower in those with uncontrolled diabetes or hyperglycemia (HbA1c). Odds of having blood stream infection were 12.1% lower, when diabetic patient in uncontrolled hyperglycemic state (OR: 0.879; 95% CI: 081-0.94; p=0.0008) (see Fig.

20). The expectation was not met in the alternative hypothesis and adjusted result showed that uncontrolled hyperglycemia had lower predictive effect on BSI among diabetic in CABG population. (see Fig. 39).

Figure 39: Multivariate analysis of Uncontrolled Hyperglycemia (HbA1c) Effect on Blood Stream Infection (BSI) in Overall Diabetic-CABG population.

Logic Regression for Blood-Stream Infection Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics Undergoing CABG surgery

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_CABG_ONLY	
Response Variable	BSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	122642
Number of Observations Used	63532
Sum of Weights Read	605630.9
Sum of Weights Used	313522.4

Response Profile			
Ordered Value	BSI	Total Frequency	Total Weight
1	1	1145	5656.85
2	0	62387	307865.58

Probability modeled is BSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-4.7856	91.7432	0.0027	0.9584
AGE		1	-0.0139	0.00144	92.4364	<.0001
Uncontrolled_HbA1c	1	1	-0.0646	0.0192	11.3338	0.0008
FEMALE	1	1	-0.0453	0.0157	8.3317	0.0039
RACE	2	1	0.1982	0.0500	15.7440	<.0001
RACE	3	1	0.1469	0.0523	7.8770	0.0050
RACE	4	1	-0.2146	0.0916	5.4905	0.0191
RACE	5	1	-0.3480	0.1462	5.6634	0.0173
RACE	6	1	0.2888	0.0594	23.6265	<.0001
ELECTIVE	0	1	-7.5062	37.5317	0.0400	0.8415
ATYPE	1	1	3.8519	18.7655	0.0421	0.8374
ATYPE	2	1	3.8856	18.7655	0.0429	0.8360
ATYPE	3	1	-11.3007	56.2984	0.0403	0.8409

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.986	0.983	0.989
Uncontrolled_HbA1c 1 vs 0	1.0000	0.879	0.815	0.947
FEMALE 1 vs 0	1.0000	0.913	0.859	0.971
RACE 2 vs 1	1.0000	1.309	1.197	1.432
RACE 3 vs 1	1.0000	1.244	1.129	1.371
RACE 4 vs 1	1.0000	0.867	0.706	1.064
RACE 5 vs 1	1.0000	0.758	0.539	1.067
RACE 6 vs 1	1.0000	1.434	1.274	1.613
ELECTIVE 0 vs 1	1.0000	<0.001	<0.001	>999.999
ATYPE 1 vs 5	1.0000	1.335	0.516	3.454
ATYPE 2 vs 5	1.0000	1.380	0.533	3.573
ATYPE 3 vs 5	1.0000	<0.001	<0.001	>999.999
LOS	1.0000	1.053	1.050	1.057

In CABG-SIMA GRAFT ONLY — Uncontrolled hyperglycemia had lower predictive effect on the rate of blood stream infection (BSI) in diabetic patients underwent CABG with SIMA grafting (OR: 0.959; 95% CI: 0.95-0.96; p<.0001). The

odds of BSI was 4.5% lower by presence of uncontrolled hyperglycemia in diabetic with SIMA grafting. The null hypothesis was rejected, however, the expectation was not met by the adjusted result that uncontrolled hyperglycemia predicts higher rate of BSI in SIMA graft subpopulation. (see Fig. 40).

Figure 40: Multivariate analysis of Uncontrolled Hyperglycemia (HbA1c) Effect on Blood Stream Infection (BSI) in Diabetic-SIMA population.

Logic Regression for Blood-Stream Infection Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) i
Diabetics with SIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_SIMA_ONLY	
Response Variable	BSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	103577
Number of Observations Used	53866
Sum of Weights Read	511701
Sum of Weights Used	265861.4

Response Profile			
Ordered Value	BSI	Total Frequency	Total Weight
1	1	875	4319.61
2	0	52991	261541.83

Probability modeled is BSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-6.8787	0.000345	398325232	<.0001
AGE		1	-0.00638	5.137E-6	1542771.26	<.0001
Uncontrolled_HbA1c	1	1	-0.0210	0.000345	3719.6720	<.0001
FEMALE	1	1	-0.0427	0.000345	15341.0978	<.0001
RACE	2	1	0.1165	0.000380	94125.3526	<.0001
RACE	3	1	0.0421	0.000385	11963.4383	<.0001
RACE	4	1	-0.0428	0.000403	11281.6565	<.0001
RACE	5	1	-0.2061	0.000406	257205.498	<.0001
RACE	6	1	0.1647	0.000393	175342.861	<.0001
ELECTIVE	0	1	-0.3138	0.000345	828892.643	<.0001
ATYPE	1	1	0.3065	0.000554	305642.273	<.0001
ATYPE	2	1	0.3267	0.000641	259534.656	<.0001
ATYPE	3	1	-0.4568	0.000604	571183.811	<.0001
ATYPE	4	1	0.3834	0.0189	410.5894	<.0001
LOS		1	0.0380	0.000019	3819150.14	<.0001

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.994	0.994	0.994
Uncontrolled_HbA1c 1 vs 0	1.0000	0.959	0.958	0.960
FEMALE 1 vs 0	1.0000	0.918	0.917	0.919
RACE 2 vs 1	1.0000	1.210	1.208	1.213
RACE 3 vs 1	1.0000	1.124	1.121	1.126
RACE 4 vs 1	1.0000	1.032	1.030	1.034
RACE 5 vs 1	1.0000	0.877	0.875	0.879
RACE 6 vs 1	1.0000	1.270	1.267	1.273
ELECTIVE 0 vs 1	1.0000	0.534	0.533	0.535
ATYPE 1 vs 5	1.0000	2.378	2.291	2.468
ATYPE 2 vs 5	1.0000	2.427	2.338	2.519
ATYPE 3 vs 5	1.0000	1.109	1.068	1.151
ATYPE 4 vs 5	1.0000	2.568	2.385	2.766
LOS	1.0000	1.039	1.039	1.039

In CABG-BIMA Graft Only — The effect of uncontrolled hyperglycemia in diabetic with BIMA grafting was not significant. The alternative hypothesis was rejected

which expect that uncontrolled hyperglycemia predicts higher rate of BSI in diabetics with BIMA grafting (OR: 1.345; 95% CI: 0.71-2.51; p=0.3537). (see Fig. 41).

Figure 41: Multivariate analysis of Uncontrolled Hyperglycemia (HbA1c) Effect on Blood Stream Infection (BSI) in Diabetic-BIMA population.

Logic Regression for Blood-Stream Infection Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics with BIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_BIMA_ONLY	
Response Variable	BSI	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	3649
Number of Observations Used	1705
Sum of Weights Read	17935.61
Sum of Weights Used	8441.62

Response Profile			
Ordered Value	BSI	Total Frequency	Total Weight
1	1	37	176.6601
2	0	1668	8264.9600

Probability modeled is BSI=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-22.5885	8604.7	0.0000	0.9979
AGE		1	-0.0511	0.0106	23.4817	<.0001
Uncontrolled_HbA1c	1	1	0.1484	0.1600	0.8600	0.3537
FEMALE	1	1	-0.0906	0.1273	0.5061	0.4769
RACE	2	1	-1.8754	0.4316	18.8862	<.0001
RACE	3	1	-0.5180	0.3769	1.8886	0.1694
RACE	4	1	0.8501	0.3769	5.0878	0.0241
RACE	5	1	1.7268	0.5262	10.7694	0.0010
RACE	6	1	0.2382	0.3136	0.5771	0.4475
ELECTIVE	0	1	-0.8400	12.1494	0.0048	0.9449
ATYPE	1	1	1.7833	24.2978	0.0054	0.9415
ATYPE	2	1	1.8259	24.2982	0.0056	0.9401

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.950	0.931	0.970
Uncontrolled_HbA1c 1 vs 0	1.0000	1.345	0.719	2.519
FEMALE 1 vs 0	1.0000	0.834	0.506	1.374
RACE 2 vs 1	1.0000	0.234	0.089	0.610
RACE 3 vs 1	1.0000	0.908	0.389	2.122
RACE 4 vs 1	1.0000	3.567	1.513	8.410
RACE 5 vs 1	1.0000	8.571	2.551	28.799
RACE 6 vs 1	1.0000	1.935	0.958	3.907
ELECTIVE 0 vs 1	1.0000	0.186	<0.001	>999.999
ATYPE 1 vs 5	1.0000	219.751	<0.001	>999.999
ATYPE 2 vs 5	1.0000	229.299	<0.001	>999.999
LOS	1.0000	1.081	1.043	1.122

The Odds of having Pneumonia (PN):

In Total CABG Population — In diabetics with uncontrolled hyperglycemia (HbA1c), the odds of pneumonia was 27.7% significantly lower by the presence of uncontrolled HbA1c relative to those with controlled hyperglycemia. The adjusted odd

ratio for pneumonia in uncontrolled versus controlled diabetes was (OR: 0.723 95% CI: 0.70-0.74; p<.0001) (see Fig. 42). This means that uncontrolled HbA1c in diabetic has less protective effect on pneumonia. Both unadjusted and adjusted result did not meet the expectation in the alternative hypothesis.

Figure 42: Multivariate analysis of Uncontrolled Hyperglycemia (HBA1c) Effect on Pneumonia (PN) in Overall Diabetic-CABG population.

Logic Regression for Pneumonia Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics Undergoing CABG surgery

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_CABG_ONLY	
Response Variable	PN	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	122642
Number of Observations Used	63532
Sum of Weights Read	605630.9
Sum of Weights Used	313522.4

Response Profile			
Ordered Value	PN	Total Frequency	Total Weight
1	1	44122	218184.94
2	0	19410	95337.49

Probability modeled is PN=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	1.0177	38.2500	0.0007	0.9788
AGE		1	-0.00104	0.000552	3.5722	0.0588
Uncontrolled_HbA1c	1	1	-0.1622	0.00740	479.9006	<.0001
FEMALE	1	1	0.00812	0.00583	1.9404	0.1636
RACE	2	1	-0.2364	0.0197	144.0151	<.0001
RACE	3	1	0.0581	0.0210	7.6807	0.0056
RACE	4	1	0.1040	0.0361	8.2841	0.0040
RACE	5	1	0.0621	0.0457	1.8470	0.1741
RACE	6	1	0.1007	0.0257	15.4017	<.0001
ELECTIVE	0	1	-1.3378	1.3014	1.0566	0.3040
ATYPE	1	1	1.0265	0.6467	2.5199	0.1124
ATYPE	2	1	0.9740	0.6467	2.2688	0.1320
ATYPE	3	1	-1.8960	1.9618	0.9340	0.3338

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.999	0.998	1.000
Uncontrolled_HbA1c 1 vs 0	1.0000	0.723	0.702	0.744
FEMALE 1 vs 0	1.0000	1.016	0.993	1.040
RACE 2 vs 1	1.0000	0.863	0.831	0.896
RACE 3 vs 1	1.0000	1.158	1.111	1.207
RACE 4 vs 1	1.0000	1.212	1.117	1.316
RACE 5 vs 1	1.0000	1.163	1.046	1.292
RACE 6 vs 1	1.0000	1.208	1.144	1.276
ELECTIVE 0 vs 1	1.0000	0.069	<0.001	11.314
ATYPE 1 vs 5	1.0000	3.099	1.742	5.512
ATYPE 2 vs 5	1.0000	2.940	1.653	5.230
ATYPE 3 vs 5	1.0000	0.167	<0.001	30.158
LOS	1.0000	0.996	0.994	0.998

In CABG-SIMA GRAFT ONLY — The adjusted result showed that the effect of uncontrolled hyperglycemia was protective in diabetic with SIMA grafting (OR: 0.725; 95% CI: 0.70-0.74; p<.0001). The odds of PN was 27.5% significantly lower by

presence of uncontrolled hyperglycemia in diabetics underwent SIMA grafting. The null hypothesis was rejected, however, both unadjusted and adjusted results were inconsistent with expectation in alternative hypothesis. (see Fig. 43).

Figure 43: Multivariate analysis of Uncontrolled Hyperglycemia (HBA1c) Effect on Pneumonia (PN) in Diabetic-SIMA population.

Logic Regression for Pneumonia Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics with SIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_SIMA_ONLY	
Response Variable	PN	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	103577
Number of Observations Used	53866
Sum of Weights Read	511701
Sum of Weights Used	265861.4

Response Profile			
Ordered Value	PN	Total Frequency	Total Weight
1	1	37747	186673.52
2	0	16119	79187.92

Probability modeled is PN=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	2.7276	44.8099	0.0037	0.9515
AGE		1	-0.00072	0.000607	1.3918	0.2381
Uncontrolled_HbA1c	1	1	-0.1608	0.00797	407.3288	<.0001
FEMALE	1	1	0.0107	0.00642	2.7608	0.0966
RACE	2	1	-0.2640	0.0214	151.6210	<.0001
RACE	3	1	0.0450	0.0228	3.8985	0.0483
RACE	4	1	0.1048	0.0394	7.0609	0.0079
RACE	5	1	0.0593	0.0491	1.4576	0.2273
RACE	6	1	0.1490	0.0281	28.0258	<.0001
ELECTIVE	0	1	-1.3208	1.3079	1.0199	0.3125
ATYPE	1	1	0.8679	0.6475	1.7965	0.1801
ATYPE	2	1	0.8053	0.6475	1.5466	0.2136
ATYPE	3	1	-2.0674	1.9769	1.0937	0.2957

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.999	0.998	1.000
Uncontrolled_HbA1c 1 vs 0	1.0000	0.725	0.703	0.748
FEMALE 1 vs 0	1.0000	1.022	0.996	1.048
RACE 2 vs 1	1.0000	0.844	0.810	0.879
RACE 3 vs 1	1.0000	1.149	1.098	1.202
RACE 4 vs 1	1.0000	1.220	1.115	1.334
RACE 5 vs 1	1.0000	1.166	1.040	1.306
RACE 6 vs 1	1.0000	1.275	1.201	1.354
ELECTIVE 0 vs 1	1.0000	0.071	<0.001	12.003
ATYPE 1 vs 5	1.0000	1.606	0.779	3.310
ATYPE 2 vs 5	1.0000	1.508	0.732	3.109
ATYPE 3 vs 5	1.0000	0.085	<0.001	16.700
LOS	1.0000	0.991	0.989	0.993

In CABG-BIMA GRAFT ONLY — The likelihood of pneumonia in diabetics with BIMA grafting subpopulation by presence of uncontrolled hyperglycemia was 31.4% lower relative to those with controlled hyperglycemia (OR: 0.686; 95% CI: 0.54-

0.86; p=0.0015) . Adjusted and unadjusted result showed the similar association between uncontrolled hyperglycemia and rate of pneumonia (PN) in diabetic patients with BIMA grafting. (see Fig. 44).

Figure 44: Multivariate analysis of Uncontrolled Hyperglycemia (HBA1c) Effect on Pneumonia (PN) in Diabetic-BIMA population.

Logic Regression for Pneumonia Rates by Presence of Uncontrolled Hyperglycemia (HbA1c) in Diabetics with BIMA Grafting Cases ONLY

The LOGISTIC Procedure

Model Information		
Data Set	SASUSER.DM_BIMA_ONLY	
Response Variable	PN	
Number of Response Levels	2	
Weight Variable	DISCWT	NIS discharge weight
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	3649
Number of Observations Used	1705
Sum of Weights Read	17935.61
Sum of Weights Used	8441.62

Response Profile			
Ordered Value	PN	Total Frequency	Total Weight
1	1	1313	6517.7571
2	0	392	1923.8629

Probability modeled is PN=1.

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	7.0848	199.1	0.0013	0.9716
AGE		1	-0.00533	0.00388	1.8885	0.1694
Uncontrolled_HbA1c	1	1	-0.1882	0.0593	10.0575	0.0015
FEMALE	1	1	0.0600	0.0460	1.6971	0.1927
RACE	2	1	0.2445	0.1423	2.9500	0.0859
RACE	3	1	0.3317	0.1519	4.7675	0.0290
RACE	4	1	-0.3920	0.2141	3.3522	0.0671
RACE	5	1	-0.5241	0.3172	2.7305	0.0984
RACE	6	1	0.2015	0.1450	1.9311	0.1646
ELECTIVE	0	1	-2.0905	40.1394	0.0027	0.9585
ATYPE	1	1	4.1691	80.2788	0.0027	0.9586
ATYPE	2	1	3.9788	80.2788	0.0025	0.9605

Odds Ratio Estimates and Wald Confidence Intervals				
Effect	Unit	Estimate	95% Confidence Limits	
AGE	1.0000	0.995	0.987	1.002
Uncontrolled_HbA1c 1 vs 0	1.0000	0.686	0.544	0.866
FEMALE 1 vs 0	1.0000	1.127	0.941	1.350
RACE 2 vs 1	1.0000	1.112	0.837	1.477
RACE 3 vs 1	1.0000	1.213	0.882	1.668
RACE 4 vs 1	1.0000	0.588	0.365	0.949
RACE 5 vs 1	1.0000	0.516	0.247	1.077
RACE 6 vs 1	1.0000	1.065	0.790	1.435
ELECTIVE 0 vs 1	1.0000	0.015	<0.001	>999.999
ATYPE 1 vs 5	1.0000	>999.999	<0.001	>999.999
ATYPE 2 vs 5	1.0000	>999.999	<0.001	>999.999
LOS	1.0000	1.008	0.990	1.026

CHAPTER 5

DISCUSSION

5.1 Interpretation of Main Findings:

The first hypothesis discusses whether diabetic patients who received bilateral internal mammary artery (BIMA) get significantly higher rate and odds of nosocomial infections compared to those who receive unilateral or signal internal mammary artery (SIMA) after GABG.. Our findings demonstrate that the use of BIMA grafting in overall CABG population had 4.2% lower predictive effect on the rate of surgical site infection (SSI) and significantly increased the risk of BSI by 46.7%, compared to SIMA graft in CABG population. The odds are slightly higher in predicting UTI by 6.9%, and PN by 6.1% with BIMA grafting in overall CABG population. In CABG diabetic population, The likelihood of SSI was significantly 23.9% lower by BIMA grafting, compared to SIMA grafting in diabetic patients. BIMA grafting has significantly increased the risk of BSI by 44.6% with no significant difference in the risk of UTI (p=0.2486), and PN (p=0.5238) in diabetic patients.

Table 14: Summary of Multivariate logistic regression model for Nosocomial Infection rates by BIMA vs. SIMA Grafting in total CABG Population.

Risk Factors	SSI			UTI			BSI			PN		
	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*
BIMA	0.958	0.95 - 0.95	<.0001	1.069	1.06 - 1.07	<.0001	1.467	1.34 - 1.60	<.0001	1.061	1.01 - 1.11	0.0114

Table 15: Summary of Multivariate logistic regression model for Nosocomial Infection rates by BIMA vs. SIMA Grafting in Diabetic-CABG cases ONLY.

Risk Factors	SSI			UTI			BSI			PN		
	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*

BIMA	**0.761**	**0.59 - 0.97**	**0.0296**	**1.066**	**0.95 - 1.18**	**0.2486**	**1.446**	**1.22 - 1.71**	**<.0001**	**0.978**	**0.91 - 1.04**	**0.5238**

Many clinical studies has documented that surgeons avoid BIMA grafting in diabetic patients due to the high risk of surgical site infection (sternal wound infection). Our finding show that BIMA grafting is less likely associated with higher risk of surgical site infection (SSI), and replicates the results of Lev-Ran, O. et al [58] that BIMA grafting had no significant difference in risk of deep sternal wound infection compared to SIMA grafting. They conducted a multivariate analysis and concluded that BIMA grafting has no correlation with the risk of sternal wound infection, suggesting that BIMA conduit can be used with acceptable risk in insulin-treated diabetic patients. Dorman, M. J. et al. [60] has drawn same conclusion that BIMA grafting has no effect on the risk of sternal wound infection, compared to SIMA in diabetic patients using propensity score-matched analysis.

In a systematic meta-analysis, Deo, S.V. et al. **[71]** suggested that BIMA grafting can be used in the diabetic patient if skeletonization harvesting technique is adopted in BIMA grafting method. It is in-situ harvesting method that skeletonized the internal thoracic artery from its connective tissue. Sajja, L. R., et al. **[72],** in a retrospective study, replicate the same conclusion that risk of sternal surgical site infection is attributable to the method of IMA harvesting method. They believe that even with the standard method of harvesting (Pedicle) BIMA grafting if modified by the surgeon to preserve the commutation of the internal thoracic artery to the chest wall, it reduce the risk of sternal SSI significantly in diabetic patients compared to SIMA grafting. These studies have indicated that internal thoracic artery grafting slightly reduce the blood flow in the chest

wall, a finding that is well-documented in anatomic cardiac studies. It contributes to low sternum blood flow, which leads to sternal ischemia and dehiscence (or mediastinitis). These complications are increased by the bilateral IMA grafting, and eventually linked to a higher risk of sternal wound infection, compared to SIMA grafting **[71],[72].**

The objective in second hypothesis (B) is to determine the effect of diabetes Mellitus on the risk of nosocomial infections in patients undergoing coronary artery bypass grafting (CABG) surgery. The bivariate analysis shows that diabetic patients have significantly lower rate of nosocomial infections than non-diabetic patients. After adjustment in multivariable analysis, our findings also confirm that Diabetes mellitus (DM) diagnosis has a significantly less predictive effect on all nosocomial infections (SSI, UTI, BSI, and PN), compared to the overall CABG population (non-diabetics). Except for UTI in BIMA graft population, diabetes was associated with higher risk of urinary tract infection (UTI). Only in patients underwent BIMA grafting [n=3,649], diabetics had 1.2 times higher risk of UTI (4.19 vs. 3.39; p=0.0393). The incidence of other infections (SSI, BSI, and PN) was significantly lower in diabetic patients. After adjustment for the possible cofounder variables, the results were consistent with bivariate analysis. The odds of UTI was significantly increased by 21.7% by presence of diabetes diagnosis in patient underwent CABG with BIMA grafting. (see table:18)

In contrary to others, our findings indicate that diabetes diagnosis was protective on almost all cases, except for UTI in BIMA graft population, in which diabetes was a strong predictor. [see Table 18]. The result was unexpected comparing to other studies included in literature review especially for SSI. [36]- [43]. For example, Zhang, X. [36] has done a meta-analysis of 132 prospective cohort studies included more than 100,000

patients conclude that diabetic patients have 1.5-1.7 times greater risk of postoperative infections than non-diabetic patients after CABG surgery.

The unexpected results in this hypothesis could imply a better trend toward the initiatives and improvements of the diabetic protocol in reducing nosocomial infections. Lemaigene A, et al. **[75],** reported similar result that diabetes showed a protective effect on SSI for insulin dependent diabetes (IDDM) (OR: 0.42; 95% CI: 0.21-0.86; p= 0.02) and non-insulin dependent diabetes (NIDDM) (OR: 0.43; 95% CI: 0.22-0.82; p= 0.01). **[75]**

In other studies, Kieser, T. M., et al. **[57]** and Lee, Y.P. et al. **[76]** concluded no significant difference in surgical site infection between diabetic and non-diabetics in CABG surgery. Kieser, T. M., et al. has reported that diabetes has no significant effect on the overall rate of surgical site infection (P=0.696 deep sternal wound infection). Lee, Y.P. et al. demonstrated the same result in bivariate analysis (P=0.336). **[57], [76]**

Table 16: Summary of Multivariate logistic regression model for Nosocomial Infection rates by BIMA vs. SIMA Grafting in total CABG Population.

Risk Factors	SSI			UTI			BSI			PN		
	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*
DM	0.449	0.41 – 0.48	<.001	0.687	0.68 - 0.68	<.0001	0.412	0.39 - 0.43	<.0001	0.449	0.43 - 0.46	<.0001

Table 17: Summary of Multivariate logistic regression model for Nosocomial Infection rates by BIMA vs. SIMA Grafting in Diabetic-CABG cases ONLY.

Risk Factors	SSI			UTI			BSI			PN		
	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*
DM	0.663	0.66 – 0.66	<.0001	0.690	0.69 – 0.69	<.0001	0.476	0.44 – 0.50	<.0001	0.457	0.44 – 0.47	<.0001

Table 18: Summary of Multivariate logistic regression model for Nosocomial Infection rates by BIMA vs. SIMA Grafting in Diabetic-CABG cases ONLY.

Risk Factors	SSI			UTI			BSI			PN		
	OR	**CI**	***P***	**OR**	**CI**	***P***	**OR**	**CI**	***P***	**OR**	**CI**	***P***
DM	**0.447**	**0.25 – 0.78**	**0.0047**	**1.217**	**1.21 – 1.22**	**<.0001**	**0.263**	**0.18 – 0.37**	**<.0001**	**0.339**	**0.28 – 0.40**	**<.0001**

The third hypothesis (C) is sub-hypothesis that the aim to test the effect of glucose control status in diabetic patients on the risk of nosocomial infections. The results in indicate that in-hospital infectious complications usually occur in diabetic patients with uncontrolled hyperglycemia (HbA1c) compared to those with controlled hyperglycemia or diabetes. Surgical site infection (SSI) and urinary tract infection (UTI) were significantly associated with uncontrolled HbA1c. Except for blood-stream infection (BSI) and pneumonia (PN), uncontrolled diabetes was not predictive factor.

The association between uncontrolled hyperglycemia and nosocomial infections: SSI and UTI was seen in overall diabetic-CABG population and Diabetic-BIMA grafting population. Diabetes with uncontrolled hyperglycemia increase the odds of SSI by 3.8% in overall CABG and 52% in BIMA graft subpopulation. Uncontrolled hyperglycemia was also a strong predictor of higher rate of urinary tract infection UTI by 20.8% in overall Diabetic-CABG sample, 20.9% in Diabetic-SIMA, and 104.9% in Diabetic-BIMA subpopulation. Uncontrolled hyperglycemia had protective effect on the rate of BSI and PN in overall CABG sample, SIMA, and BIMA subpopulation.

Table 19: Summary of Multivariate logistic regression model for Nosocomial Infection rates By presence of Uncontrolled Hyperglycemia in total CABG population.

Risk Factors	SSI			UTI			BSI			PN		
	OR	**CI**	***P***	**OR**	**CI**	***P***	**OR**	**CI**	***P***	**OR**	**CI**	***P***

Unctrl HbA1c	**1.038**	**1.03 – 1.04**	**<.0001**	**1.208**	**1.15 – 1.26**	**<.0001**	**0.879**	**0.81 – 0.94**	**0.0008**	**0.723**	**0.70 – 0.74**	**<.0001**

Table 20: Summary of Multivariate logistic regression model for Nosocomial Infection rates By presence of Uncontrolled Hyperglycemia in CABG-SIMA GRAFT Cases ONLY.

Risk Factors	**SSI**			**UTI**			**BSI**			**PN**		
	OR	**CI**	***P***	**OR**	**CI**	***P***	**OR**	**CI**	***P***	**OR**	**CI**	***P***
Unctrl HbA1c	**0.937**	**0.84 – 1.03**	**0.2020**	**1.209**	**1.15 – 1.26**	**<.0001**	**0.959**	**0.95 – 0.96**	**<.0001**	**0.725**	**0.70 – 0.74**	**<.0001**

Table 21: Summary of Multivariate logistic regression model for Nosocomial Infection rates By presence of Uncontrolled Hyperglycemia in CABG-BIMA GRAFT Cases ONLY.

Risk Factors	**SSI**			**UTI**			**BSI**			**PN**		
	OR	**CI**	***P***	**OR**	**CI**	***P***	**OR**	**CI**	***P***	**OR**	**CI**	***P***
Unctrl HbA1c	**1.520**	**1.50 – 1.53**	**<.0001**	**2.049**	**1.45 – 2.89**	**<.0001**	**1.345**	**0.71 – 2.51**	**0.3537**	**0.686**	**0.54 – 0.86**	**0.0015**

The results met our expectation in the hypothesis (C) and were consistent Subramaniam, B., et al. [46], and Ng, R. R., et al. [50]. Subarmaniam B., et al. showed that preoperative uncontrolled hyperglycemia significantly increases risk of deep sternal wound infection by 64% (OR: 1.64) with no significant difference in pneumonia (p=0.704). Ng. R. R. et al. [50] study concluded that diabetic with blood glucose > 8 mmol/L have a 213% increase risk of surgical site infection (OR 3.131 (95% CI: 1.431 - 6.851), *P* = 0.004). A target glucose less than <8 mmol/L is highly recommend for diabetic patients to be range between 7.4 to 7.7 mmol/L. [50]

The coexistence of diabetes and uncontrolled hyperglycemia are important risk factors for operative infection. It is well document in clinical and laboratory studies that the long-term complication of diabetes cause poor blood profusion due to the

pathological changes in microvascular permeability, which debilitates injury healing process and immunity to infections. At molecular level also, long term complication of hyperglycemia in diabetes has been associated with impairment of the polymorphonuclear neutrophils' chemotactic and phagocytic functionality. **[73], [74].** It has been emphasized by American heart association and the society of thoracic surgeons guidelines for surgeons that target glucose have to be less than 6 mmol/L for diabetic patients undergoing CABG surgery**. [50], [77]**

CHAPTER 6

CONCLUSION

6.1 Final Statement:

Diabetic patients showed a lower trend in all noscomial infection rate, except for UTI in BIMA graft population. The findings suggest a positive trend in nosomical infection for diabetic patients, however, measures to protect patients at risk like those with diabetes is very important. New applied protocols toward the national effort in safer clinical practice could contribute to an unexpected trend change in certain outcomes. This could indicate a better trend in diabetic protocols as well.

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The BIMA grafting should be encouraged in diabetic patients. Expect in the case of uncontrolled hyperglycemia due to the high risk of both SSI and UTI as it has been emphasized in literature and was consistent with our findings. It is based on the surgeon preference in the choice of BIMA grafting in the diabetic patients with uncontrolled hyperglycemia, However, we highly recommend the aggressive hyperglycemia control protocol by continuous insulin infusion based on our findings.

6.2 Limitations:

A major limitation of our study is that the ICD-9-CM codes in HCUP data are intended for administrative and billing purposes. The sensitivity of ICD-9 codes representation to define a clinical adverse events rate might not be fully accurate. Some studies might have a different set of ICD9 codes to retrieve clinical scenarios with nosocomial infections. This variability could be a source of pitfall. A standardized

method is needed on how to increase the sensitivity and representation of ICD-9 code to detect the nosocomial infectious complications in administrative data. Until now, there is no worldwide standard method on detecting health-care associated infections in administrative data.

Secondly, HCUP data was not designed to track adverse event over time. The time of events incidence was not clear to be identified whether to be after (post-operative) or before (pre-operative) CABG surgery. Therefore, we captured all targeted infections happened during hospitalization in CABG population.

Other limitations are associated with the type of research design. Retrospective research is subject to selection bias. Some adjustment in the statistical analysis can be used to improve the results with selection bias. For example, propensity score analysis can be used to reduce the selection bias that results from selection of the variables used for comparing the exposure groups baseline characteristics.

6.3 Future Research:

In the future work, a study is needed to conduct a pathogens profiling analysis of nosocoimal infections in Diabetic patients undergoing CABG Surgery. It is important to analyze the risk factors associated with antibiotic-resistant pathogens in SSI, UTI, BSI, and PN in CABG surgery. The study also could measure the effect of Nosocomial Infection on the hospital resources in cost and length of stay.

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APPENDIX A

Medline Database Search Strings

No.	PubMed String	Records Number
1	CABG[tw] OR PCI[tw] OR PTCA[tw] AND hba1c[tw]	83
2	"cross infection"[MeSH Major Topic] OR (("infection"[MeSH Terms] OR "infection"[All Fields] OR "infections"[All Fields]) AND "control groups"[MeSH Terms]) AND "cardiovascular surgical procedures"[MeSH Major Topic] AND diabetes[tw]	21
3	"Cardiovascular Surgical Procedures"[Majr] AND (Hb A1a+b or Hb A1c or HbA1 or Glycosylated Hemoglobin A or Hb A1 or Glycohemoglobin A or Hemoglobin A(1) or Hemoglobin, Glycosylated A1b or A1b Hemoglobin, Glycosylated or Glycosylated A1b Hemoglobin or Hb A1b or Hemoglobin, Glycosylated A1a-1 or A1a-1 Hemoglobin, Glycosylated or Glycosylated A1a-1 Hemoglobin or Hemoglobin, Glycosylated A1a 1 or Hb A1a-1 or Hb A1a-2 or Hemoglobin, Glycosylated or Glycosylated Hemoglobin or Glycated Hemoglobins or Hemoglobins, Glycated)	148
4	("Cardiovascular Surgical Procedures"[Majr] AND "Glucose Metabolism Disorders"[Mesh]) AND "Infection"[Mesh]	116
5	("myocardial revascularization"[MeSH Terms] OR ("myocardial"[All Fields] AND "revascularization"[All Fields]) OR "myocardial revascularization"[All Fields] OR ("myocardial"[All Fields] AND "revascularizations"[All Fields]) OR "myocardial revascularizations"[All Fields]) AND (("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR "hb a1a b"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hb"[All Fields] AND "a1c"[All Fields]) OR "hb a1c"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR "hba1"[All Fields]) OR ("glycosylated haemoglobin a"[All Fields] OR "hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hb"[All Fields] AND "a1"[All Fields]) OR "hb a1"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR "glycohemoglobin a"[All Fields]) OR ("haemoglobin a"[All Fields] OR "hemoglobin a"[MeSH Terms] OR "hemoglobin a"[All Fields]) AND 1[All Fields] OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hemoglobin"[All Fields] AND "glycosylated"[All Fields] AND "a1b"[All Fields])) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("a1b"[All Fields] AND "hemoglobin"[All Fields] AND "glycosylated"[All Fields])) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("glycosylated"[All Fields] AND "a1b"[All Fields] AND "hemoglobin"[All Fields]) OR	151

	"glycosylated a1b hemoglobin"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hb"[All Fields] AND "a1b"[All Fields]) OR "hb a1b"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hemoglobin"[All Fields] AND "glycosylated"[All Fields]) OR "hemoglobin, glycosylated"[All Fields]) OR ("glycosylated haemoglobin"[All Fields] OR "hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("glycosylated"[All Fields] AND "hemoglobin"[All Fields]) OR "glycosylated hemoglobin"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("glycated"[All Fields] AND "hemoglobins"[All Fields]) OR "glycated hemoglobins"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hemoglobins"[All Fields] AND "glycated"[All Fields])))	
6	"Cardiovascular Surgical Procedures"[Majr] AND (("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR "hb a1a b"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hb"[All Fields] AND "a1c"[All Fields]) OR "hb a1c"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR "hba1"[All Fields]) OR ("glycosylated haemoglobin a"[All Fields] OR "hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hb"[All Fields] AND "a1"[All Fields]) OR "hb a1"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR "glycohemoglobin a"[All Fields]) OR ("haemoglobin a"[All Fields] OR "hemoglobin a"[MeSH Terms] OR "hemoglobin a"[All Fields]) AND 1[All Fields] OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hemoglobin"[All Fields] AND "glycosylated"[All Fields] AND "a1b"[All Fields])) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("a1b"[All Fields] AND "hemoglobin"[All Fields] AND "glycosylated"[All Fields])) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("glycosylated"[All Fields] AND "a1b"[All Fields] AND "hemoglobin"[All Fields]) OR "glycosylated a1b hemoglobin"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hb"[All Fields] AND "a1b"[All Fields]) OR "hb	148

	a1b"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hemoglobin"[All Fields] AND "glycosylated"[All Fields]) OR "hemoglobin, glycosylated"[All Fields]) OR ("glycosylated haemoglobin"[All Fields] OR "hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("glycosylated"[All Fields] AND "hemoglobin"[All Fields]) OR "glycosylated hemoglobin"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("glycated"[All Fields] AND "hemoglobins"[All Fields]) OR "glycated hemoglobins"[All Fields]) OR ("hemoglobin a, glycosylated"[MeSH Terms] OR "glycosylated hemoglobin a"[All Fields] OR ("hemoglobins"[All Fields] AND "glycated"[All Fields])))	
8	("hyperglycaemia"[All Fields] OR "hyperglycemia"[MeSH Terms] OR "hyperglycemia"[All Fields]) AND (predict$[All Fields] OR clinical$[All Fields] OR outcome$[All Fields] OR ("risk"[MeSH Terms] OR "risk"[All Fields])) AND ("coronary artery bypass"[MeSH Terms] OR ("coronary"[All Fields] AND "artery"[All Fields] AND "bypass"[All Fields]) OR "coronary artery bypass"[All Fields])	145
10	myocardial revascularization[majr] and Glycosylated haemoglobin[mesh]	81
11	percutaneous coronary intervention AND GLYCEMIC CONTROL	68
12	CORONARY ARTERY BYPASS and glycemic control	113
13	(Therapy/Broad[filter]) AND ((cross infection or nosocomial infection or hospital acquired infection) and myocardial revascularization and diabetes)	26
14	LINKED Citation FROM PubMed paper " Is there a role for HbA1c in predicting mortality and morbidity outcomes after coronary artery bypass graft surgery?	349
	(("diabetes mellitus"[MeSH Terms] OR ("diabetes"[All Fields] AND "mellitus"[All Fields]) OR "diabetes mellitus"[All Fields]) AND ("blood glucose"[MeSH Terms] OR ("blood"[All Fields] AND "glucose"[All Fields]) OR "blood glucose"[All Fields]) AND ("infection"[MeSH Terms] OR "infection"[All Fields])) AND ("myocardial revascularisation"[All Fields] OR "myocardial revascularization"[MeSH Terms] OR ("myocardial"[All Fields] AND "revascularization"[All Fields]) OR "myocardial revascularization"[All Fields])	36
	"internal mammary-coronary artery anastomosis"[MeSH Terms] AND "diabetes complications"[MeSH Terms]	47

	((myocardial revascularization[MeSH Terms]) AND infection[Text Word]) AND diabetes mellitus[MeSH]	170
	(Therapy/Broad[filter]) AND (drug-eluting stents and infection)	54
	(etiology/Broad[filter]) AND (percutaneous coronary intervention and coronary artery bypass grafting surgery and diabetes)	889

APPENDIX B

ICD-9-CM codes Definition of The Study Sample Population, Outcomes, and Exposures

A: Definition of Population undergoing CABG Procedures by ICD-9 codes	
Primary Procedure (PR1)	ICD-9-CM
CABG [CSS1=44]	3610, 3611, 3612, 3613, 3614, 3615, 3616, 3617, 3618, 3619, 3619, 363, 3631, 3632, 3633, 3634,3639
Cardiopulmonary bypass (on-pump)	3961
Aortic coronary bypass grafting	3610, 3611, 3612, 3613, 3614
Single Internal Mammary grafting anastomosis or grafting (SIMA)	3615
Bilateral (Double) internal mammary anastomosis or grafting (BIMA)	3616
Abdominal bypass grafting	3617
Other bypass anastomosis or grafting	3619, 363, 3631, 3632, 3633, 3634,3639
Primary Diagnosis* (Dx1) only	ICD-9-CM
* It is auto generated by filtering the primary procedure (Pr1) for CABG surgery. Coronary Heart Disease (CHD), Coronary atherosclerosis, Acute myocaridal infarction, Acute coronary syndrome, or Angina pectoris, or chronic heart disease. [CCS=100, CCS=101]	41000, 41001, 41010, 41011, 41012, 41012, 41012, 41020, 41021, 41022, 41030, 41031, 41032, 41040, 41041, 41042, 41050, 41051, 41052, 41060, 41061, 41062, 41070, 41071, 41072, 41080, 41081, 41082, 41090, 41091, 41092, 4110, 4111, 41181, 4130, 4131, 4139, 4140, 41400, 41401, 41402, 41403, 41404, 41405, 41406, 41407, 4141, 41410, 41411, 41412, 41419, 4142, 4143, 4148, 4149.
ICD-9-CM : International Classification of Diseases, 9th Revision, Clinical Modification from http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp#download . * Diabetes complications are ketoacidosis[a], hyperosmolarity[b], coma[c], nephropathy[d], ophthalmopathy[e], neuropathy[f], vascular manifestation [g], unspecified, and other complications	

B: Definition of Outcome Indicator Variables for postoperative complications.	
Any Secondary Diagnosis (DXs) with	ICD-9-CM
Complications of surgical Procedures (CCS 238)	
Surgical site infection (SSIs) or post-operative infections or Infection of internal prosthetic device; implant; and grafts	5192 996.60, 996.61, 996.62 998.31, 998.32, 998.5, 998.51, 998.59, 998.83
Sepsis / blood stream infections (BSIs)	0380 0381 03810 03811 03812 03819 0384203840 03841 03843 03844 03849 038.0–038.4, 038–038.9, 785.52, 790.7, 995.9, 995.91, 995.92, 996.60, 996.61, 996.62, 998.0, 999.3, 999.31, 999.39
Pneumonia [122]	997.3, 997.31, 997.39 480, 480.0, 480.1, 480.2, 480.3, 480.8, 480.9, 481, 482, 482.0, 482.1, 482.2, 482.3,482.30, 482.31, 482.32, 482.39, 482.40, 482.41, 482.42, 482.49, 482.8, 482.81,482,82, 482.83, 482.84, 482.89, 482.9 483, 483.1, 483.8, 484, 484.1, 484.3, 484.5, 484.6, 484.7, 484.8, 485, 486 487.0
Urinary Tract infections (UTIs)	599.0, 996.64
ICD-9-CM : International Classification of Diseases, 9th Revision, Clinical Modification from http://www.hcup-us.ahrq.gov/toolssoftware/ccs/AppendixCMultiDX.txt .	

C: Definition of Exposure	
Any Secondary Diagnosis (Dx2-Dx15)	ICD-9-CM
Diabetes w/o complication [CSS=49] and	25000, 25001, 25002, 25003, 24900, 24901
Diabetes w/ complications [CSS=50] *	25010-25013 [a] , 25020-25023 [b] , 25030-25033[c] , 25040-25043 [d] , 25050-25053[e] ,2560-2563[f] , 25070-2573[g] , 25080-2583[h] ,25090-2593[i] , 24910-24911,249.20-24921,24930-24931,24940-24941,24950-24951,24960-24961, 24970-24971,24980-24981,24991-249.90.
Any Secondary Diagnosis (Dx2-Dx15) with	ICD-9-CM
Diabetes with Uncontrolled Hyperglycemia	25002, 25003, 24901,25012, 25022, 25042, 25052, 25062, 25072, 25082, 25092, 25013, 25023, 25033, 25043, 25053, 25063, 25073, 25083, 25093 , 24911, 24921, 24931, 24941, 24951, 24961, 24971, 24981, 24991.
Abnormal glucose level	7902
Elevated or Impaired fasting glucose	79021
Impaired glucose tolerance test	79022
Unspecific hyperglycemia	79029
Any Procedure (PRx) with	
Single Internal Mammary grafting anastomosis or grafting (SIMA)	3615
Bilateral (Double) internal mammary anastomosis or grafting (BIMA)	3616
ICD-9-CM : International Classification of Diseases, 9th Revision, Clinical Modification. CCS: Clinical Classification Software for ICD-9-CM codes. CABG= Coronary artery bypass graft; PCI= Percutaneous coronary intervention	