Addressing Healthcare Acquired Infections: CLABSI and SSI

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1.0 Background

On any given day, about one in 31 hospital patients has at least one healthcare-associated infection (HAI).

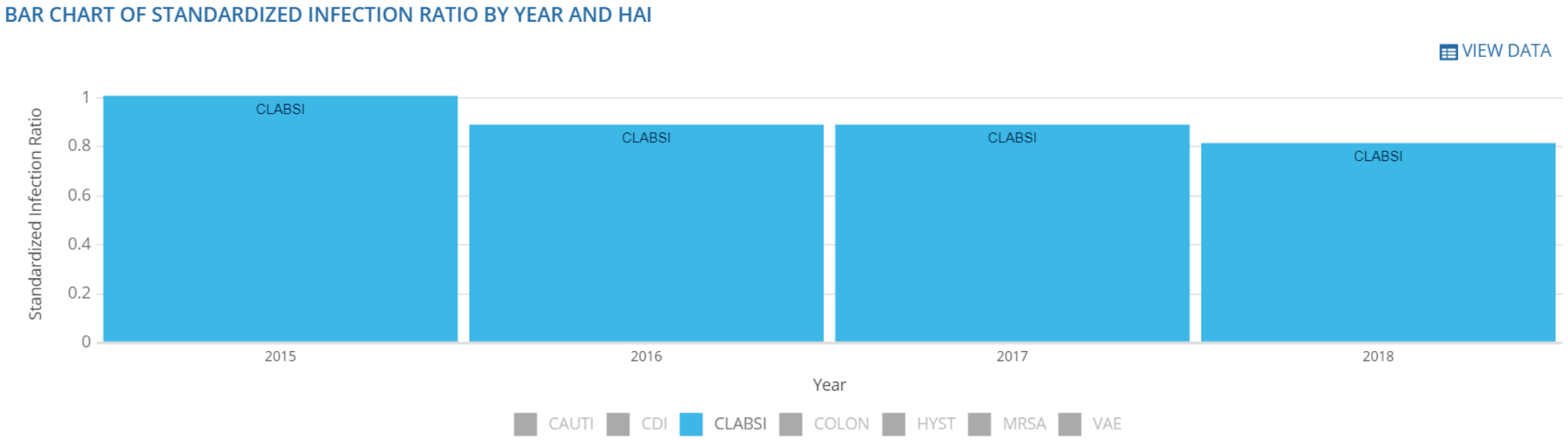
HAI are infections that patients can acquire during their stay in the hospital. They can have devastating effects on physical, mental/emotional, and financial health. In addition, they cost billions of dollars in added expenses to the healthcare system.

Some laws have been put into place to report these infections to the public and to help managing and preventing them.

Surgical site infections (SSIs) are serious operative complications that occur in approximately 2% of surgical procedures and account for some 20% of health care-associated infections.

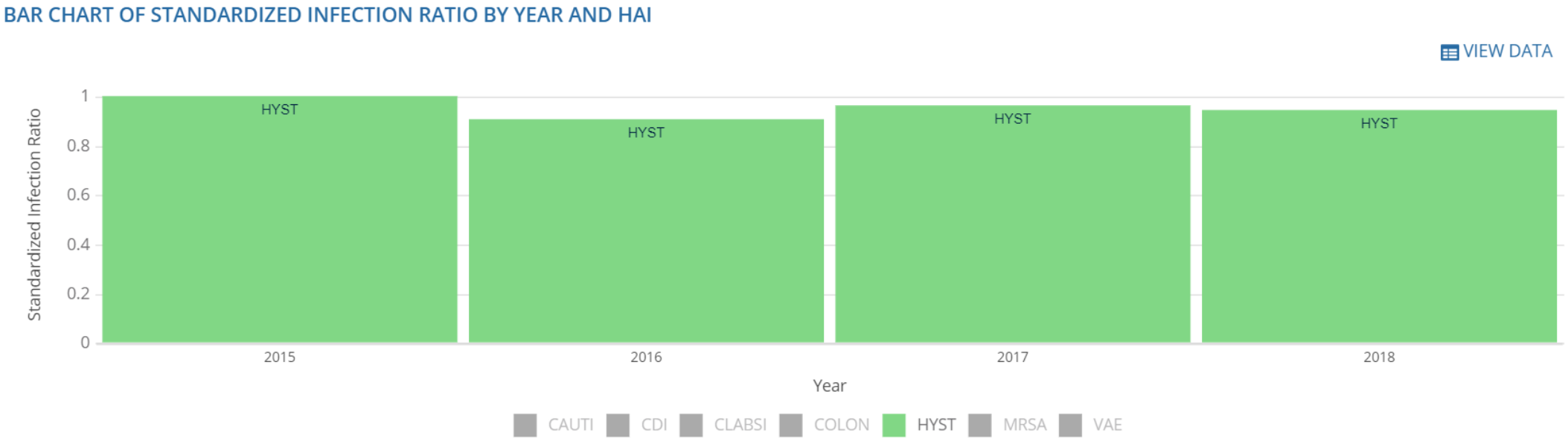
CLABSI

- A central line-associated bloodstream infection (CLABSI) is a serious infection that occurs when germs (usually bacteria or fungi) enter the bloodstream through a central line.
- Healthcare providers must follow a strict protocol when inserting the line to make sure the line remains sterile and a CLABSI does not occur.
- In addition to inserting the central line properly, healthcare providers must use stringent infection control practices each time they check the line or change the dressing.



SSI

- A surgical site infection (SSI) is an infection that occurs after surgery in the part of the body where the surgery took place.
- SSIs can be superficial infections involving the skin only.
- Others are more serious and can involve tissues under the skin, internal organs, or implanted material.
- **Abdominal Hysterectomy** infections and colon surgery infections are the two SSI types that are reported by all or most acute care hospitals in most states in the U.S. They can impact hospitals' relative rankings around quality metrics used to determine financial penalties.



HAIs: The Hospitals of Providence (THOP)

Medicare.gov | Hospital Compare
The Official U.S. Government Site for Medicare

Infections - details

Table 1 of 6 Central line-associated bloodstream infections (CLABSI) in ICUs and select wards

	No. of Infections Reported (A)	Central Line Days (CLDs)	Predicted No. Infections (B)	Standardized Infection Ratio (SIR) (A/B)	Evaluation
THE HOSPITALS OF PROVIDENCE MEMORIAL CAMPUS	0	5231	5.264	0.000	Better than the National Benchmark

Standardized infection ratio (SIR) national benchmark = 1.
Lower SIRs are better. A score of (0) – meaning no CLABSIs - is best.

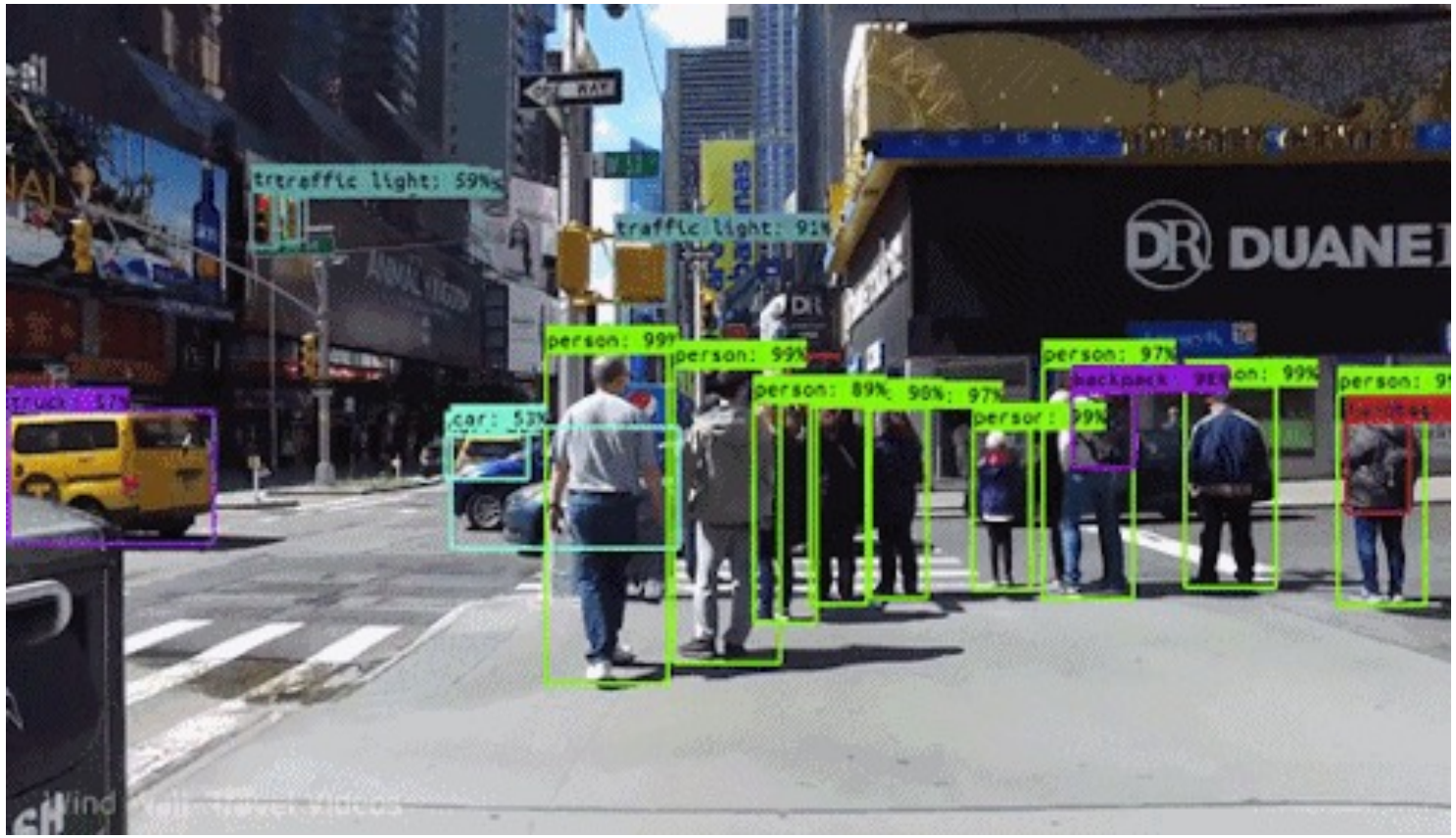
Table 3 of 6 Surgical site infections (SSI) from colon surgery

	No. of Infections Reported (A)	Number of Procedures	Predicted No. Infections (B)	Standardized Infection Ratio (SIR) (A/B)	Evaluation
THE HOSPITALS OF PROVIDENCE MEMORIAL CAMPUS	1	88	2.156	0.464	No Different than National Benchmark

Standardized infection ratio (SIR) national benchmark = 1.
Lower SIRs are better. A score of (0) – meaning no SSI: Colons - is best.

4.0 Methodology: Poka Yoke

- Poka Yoke or Mistake proofing is a simple technique that developed out of the Toyota Production system.
- Purposes:
  - Not accept a defect for the process
  - Not Create a Defect
  - Not Allow a Defect to be passed to the next process
- How to apply it:
  - Control>Measure>Detection
  - Warning > Prevention



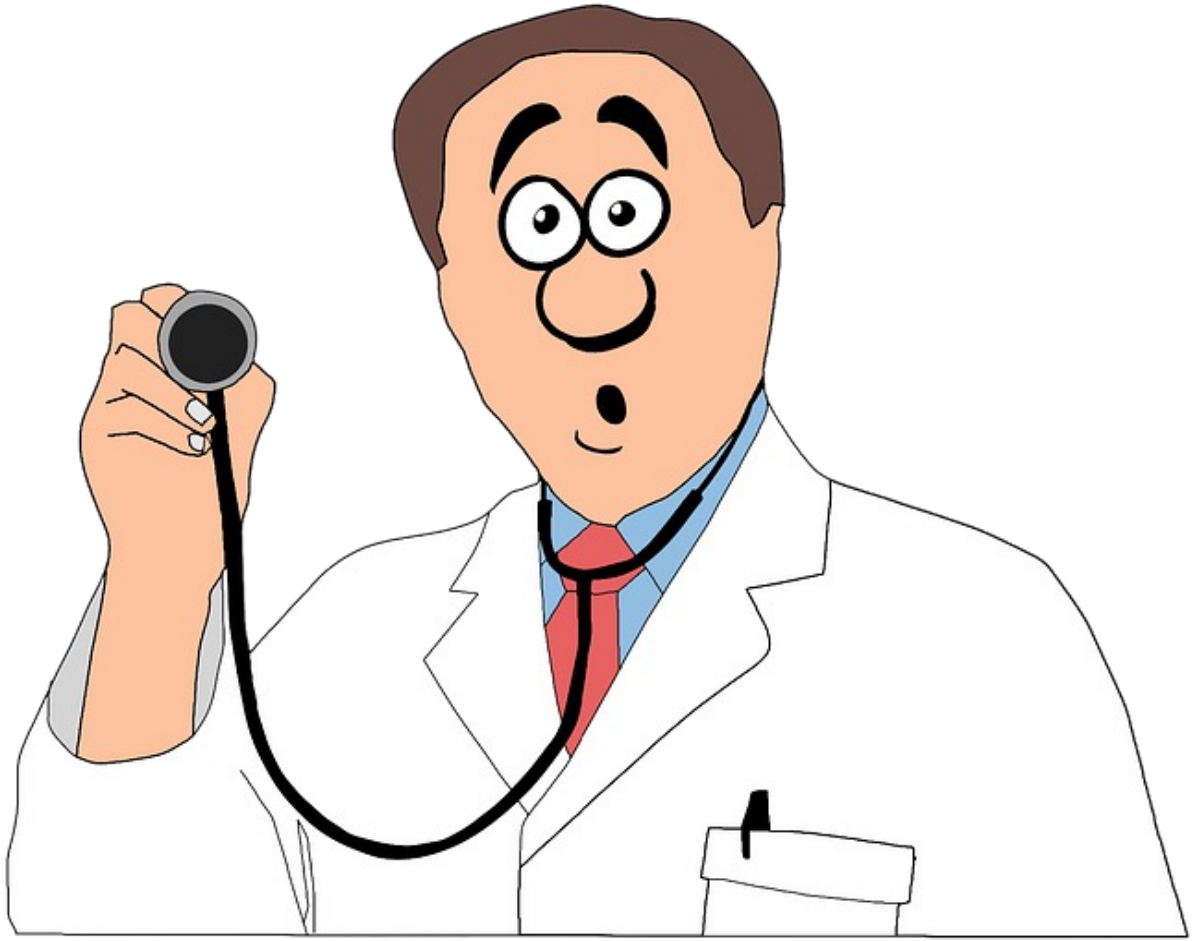
4.0 Methodology: Poka Yoke

DETECTION

- CLABSI's negative binomial regression
- SSI's logistic regression
- Patient's dataset analysis

PREVENTION

- SSI prevention strategies
- CLABSI prevention strategies



Detection

Logistic Regression to Calculate SSI Risk Factors

- Logistic regression is used widely to examine and describe the relationship between a binary response variable (e.g., ‘success’ or ‘failure’) and a set of predictor variables.

$$P = \frac{1}{1+e^{-(\beta_0+\beta_1 X_1+\beta_2 X_2+\ldots\beta_n X_n)}} = \frac{1}{1+e^{-(\beta_0+\sum \beta_i X_i)}}.$$

Model

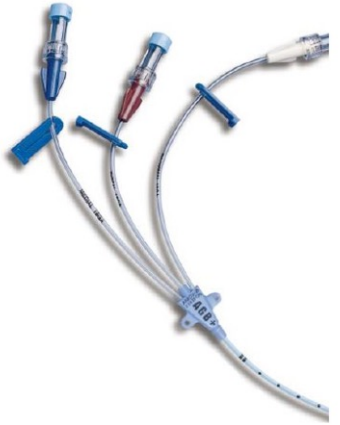
NHSN Standardized Infection Ratio (2019) shows the risk factors for complex 30-day model for abdominal hysterectomy (HYST) procedures

Factor	Parameter Estimate	P-value	Variable Coding
Intercept	-5.1801	-	-
Diabetes	0.3247	<0.0001	Yes=1, No=0
ASA Score	0.4414	<0.0001	1=1, 2=2, 3=3 4&5=4
Body Mass Index (BMI)	0.1106	0.009	≥30=1, <30=0
Patient Age	-0.1501	<0.0001	Patient Age/10
Oncology Hospital	0.5474	0.0005	Oncology Hospital=1, Non-oncology Hospital=4

- $logit\ (\hat{p}) = -5.1801 + 0.3247(DIABETES) + 0.4414(ASA) + 0.1106(BMI) - 0.1501(AGE) + 0.5474(ONCOLOGY\ HOSPITAL)$
- $\hat{p} = e^{\ logit(\hat{p})} / 1 + e^{\ logit(\hat{p})}$

CLABSI Risk Factors

- Age
- Gender
- Duration of Catheterization
- Diabetes Mellitus
- Recent Chemotherapy
- Multiple Lumen Catheters



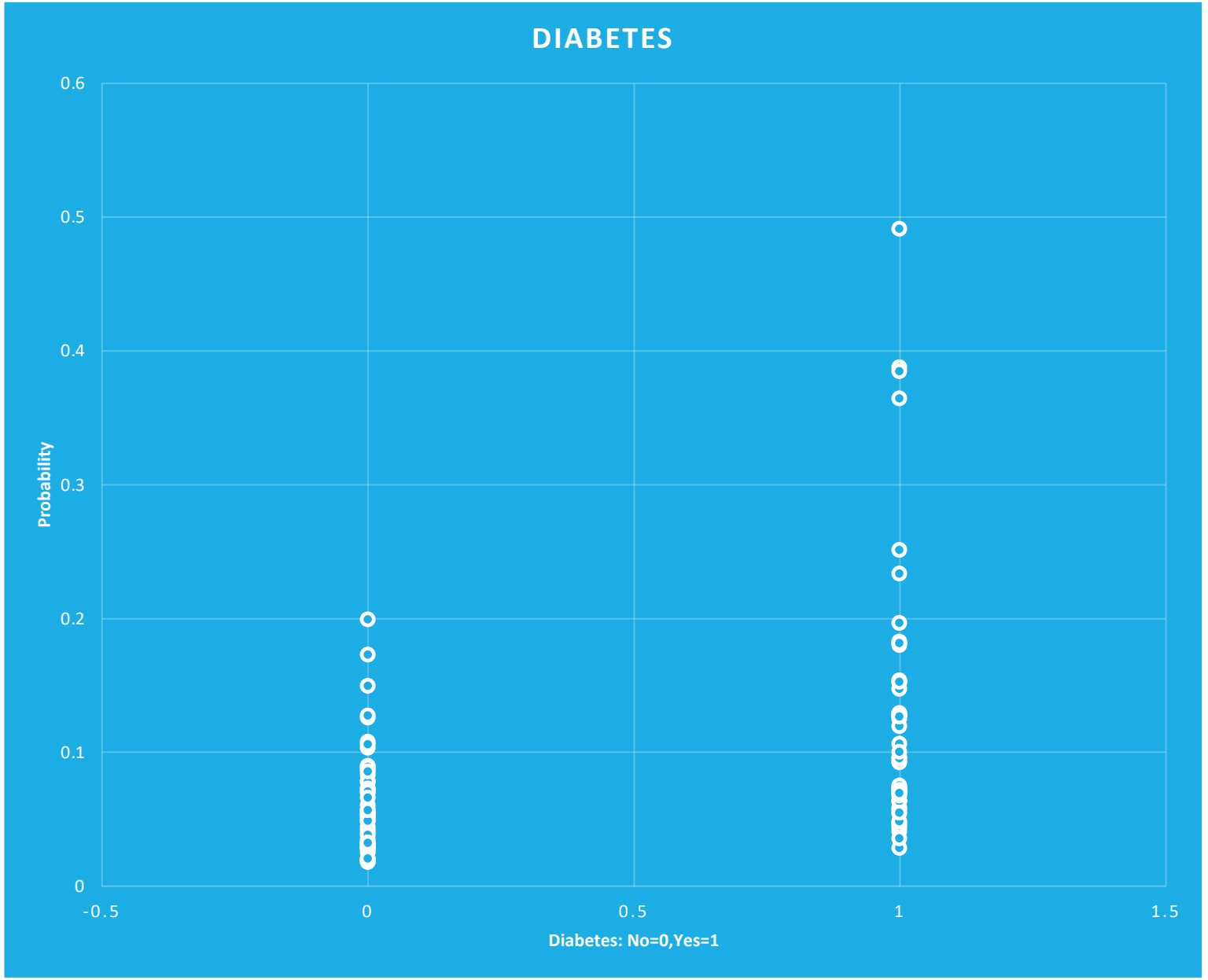
Features	Frequency
Age	5
Duration of catheterization	4
Gender	3
Recent chemotherapy	3
Multiple Lumens Catheters	3
Diabetes mellitus	2
Complexity of disease	2
Hemodialysis	2
Foley catheterization	2
CVC	2
Parental Nutrition	2
Malignancy	2
Peripherally inserted central catheter (PICC) tip malposition	1

Dataset

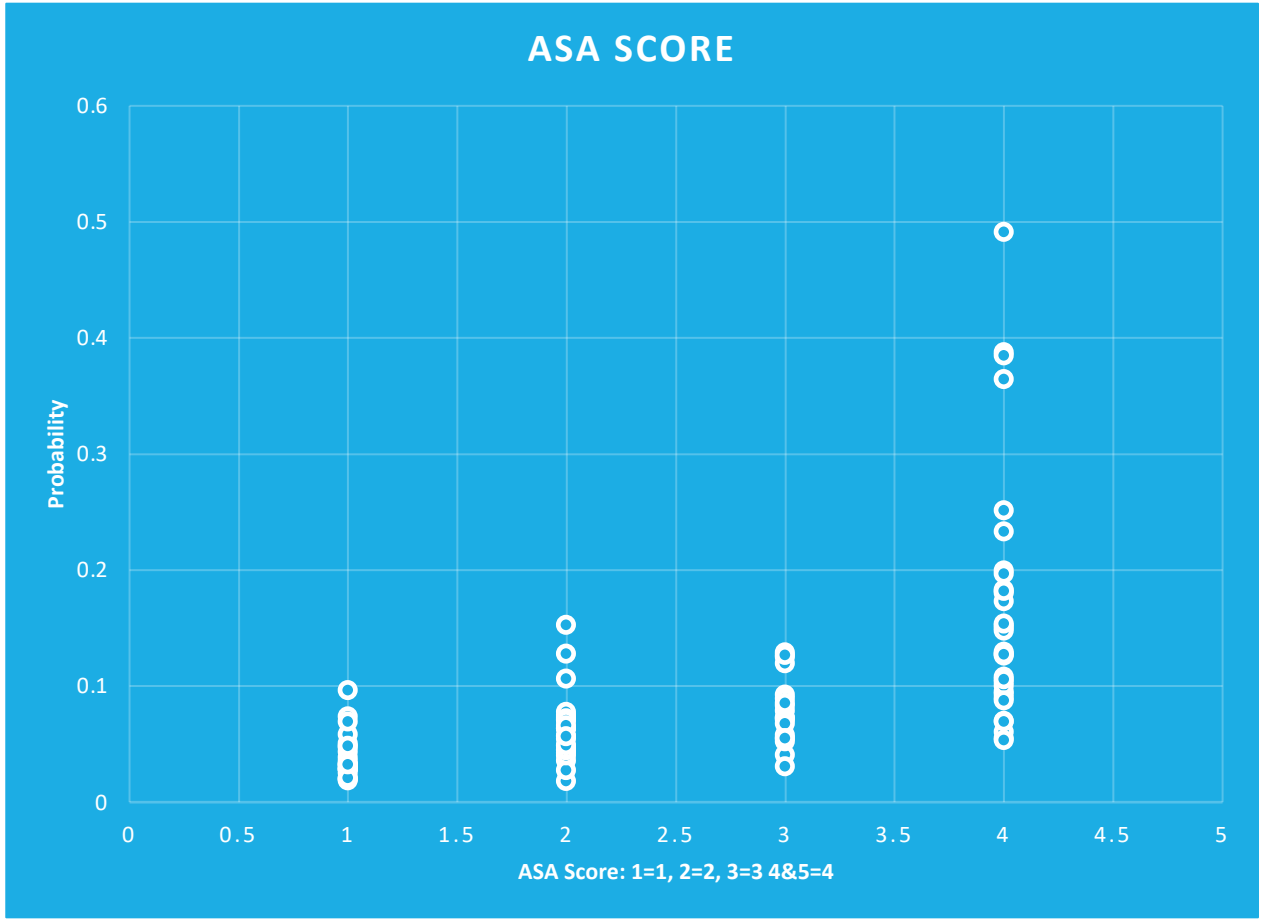
- $logit\ (\hat{p}) = -5.1801 + 0.3247(DIABETES) + 0.4414(ASA) + 0.1106(BMI) - 0.1501(AGE) + 0.5474(ONCOLOGY\ HOSPITAL)$
- $\hat{p} = e^{\ logit(\hat{p})} / 1 + e^{\ logit(\hat{p})}$

Patient	Intercept	Diabetes	ASA Score	BMI	Age	Age/10	Oncology	Logit($\hat{p}$)	Probability ($\hat{p}$)
1	-5.1801	0	3	0	79	7.9	1	-2.12271	0.135985125
2	-5.1801	0	4	1	56	5.6	1	-1.91594	0.17261255
3	-5.1801	1	3	0	65	6.5	1	-2.00815	0.155050227
4	-5.1801	0	3	1	51	5.1	1	-2.43239	0.096282881
5	-5.1801	1	4	0	20	2	1	-2.2422	0.118849263
6	-5.1801	1	1	0	81	8.1	0	-3.19819	0.04257463
7	-5.1801	0	1	0	47	4.7	1	-3.48583	0.031596061
8	-5.1801	0	3	1	40	4	1	-2.5975	0.080449742
9	-5.1801	0	4	1	81	8.1	0	-2.08809	0.141452965
99	-5.1801	0	2	1	70	7	0	-3.136	0.045430517
100	-5.1801	0	1	0	40	4	1	-3.5909	0.02835536

Analyses: Diabetes

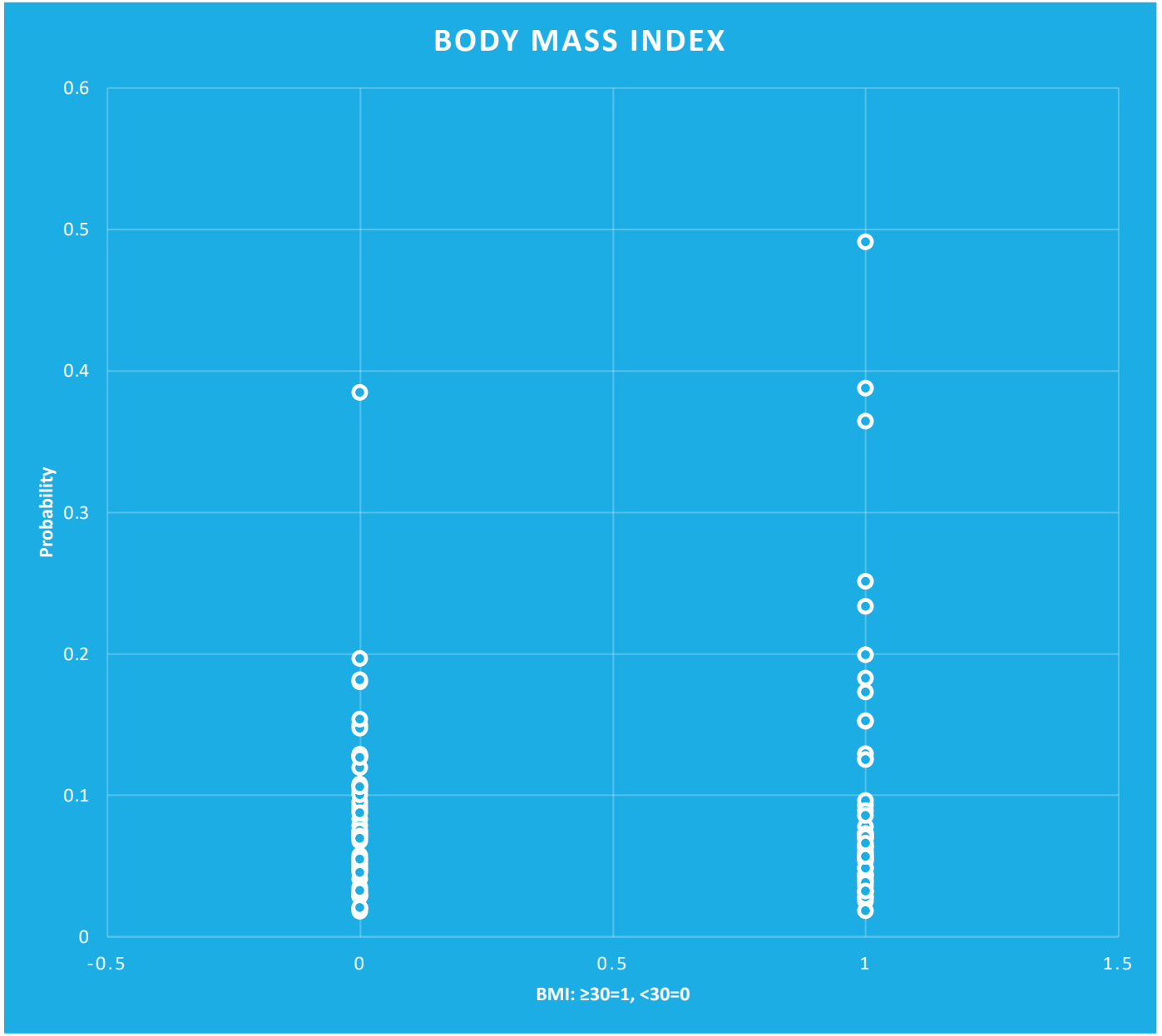


Analyses: ASA Score

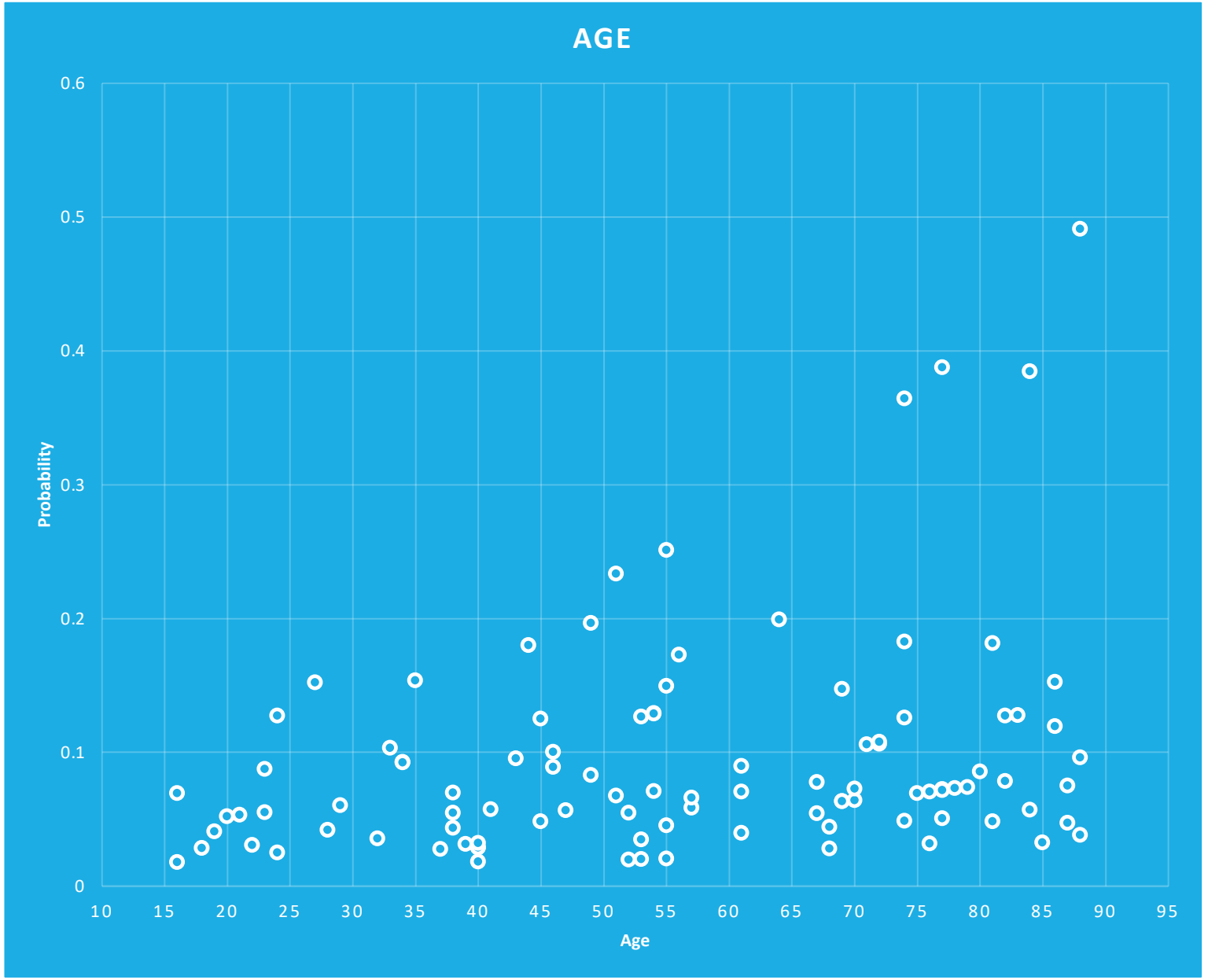


ASA PS Classification	Definition
ASA I	A normal healthy patient
ASA II	A patient with mild systemic disease
ASA III	A patient with severe systemic disease
ASA IV	A patient with severe systemic disease that is a constant threat to life
ASA V	A moribund patient who is not expected to survive without the operation
ASA VI	A declared brain-dead patient whose organs are being removed for donor purposes

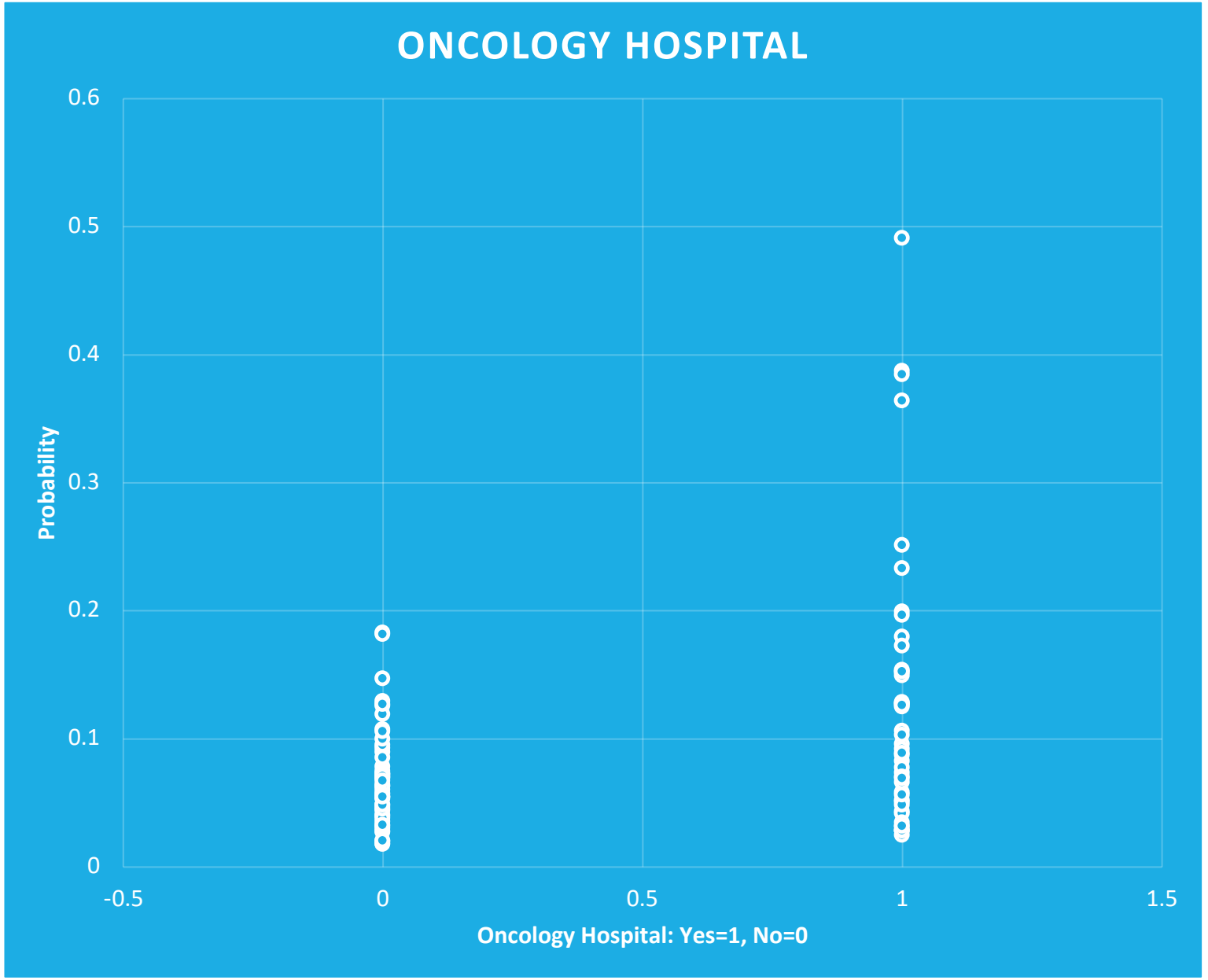
Analyses: BMI



Analyses: Age (15-90)



Analyses: Oncology Hospitals



Negative Binomial Regression to calculate CLABSI Factors

- Negative binomial regression is for modeling count variables, usually for over-dispersed count outcome variables.
- Variance and mean are not equivalent.

Probability Mass Function:

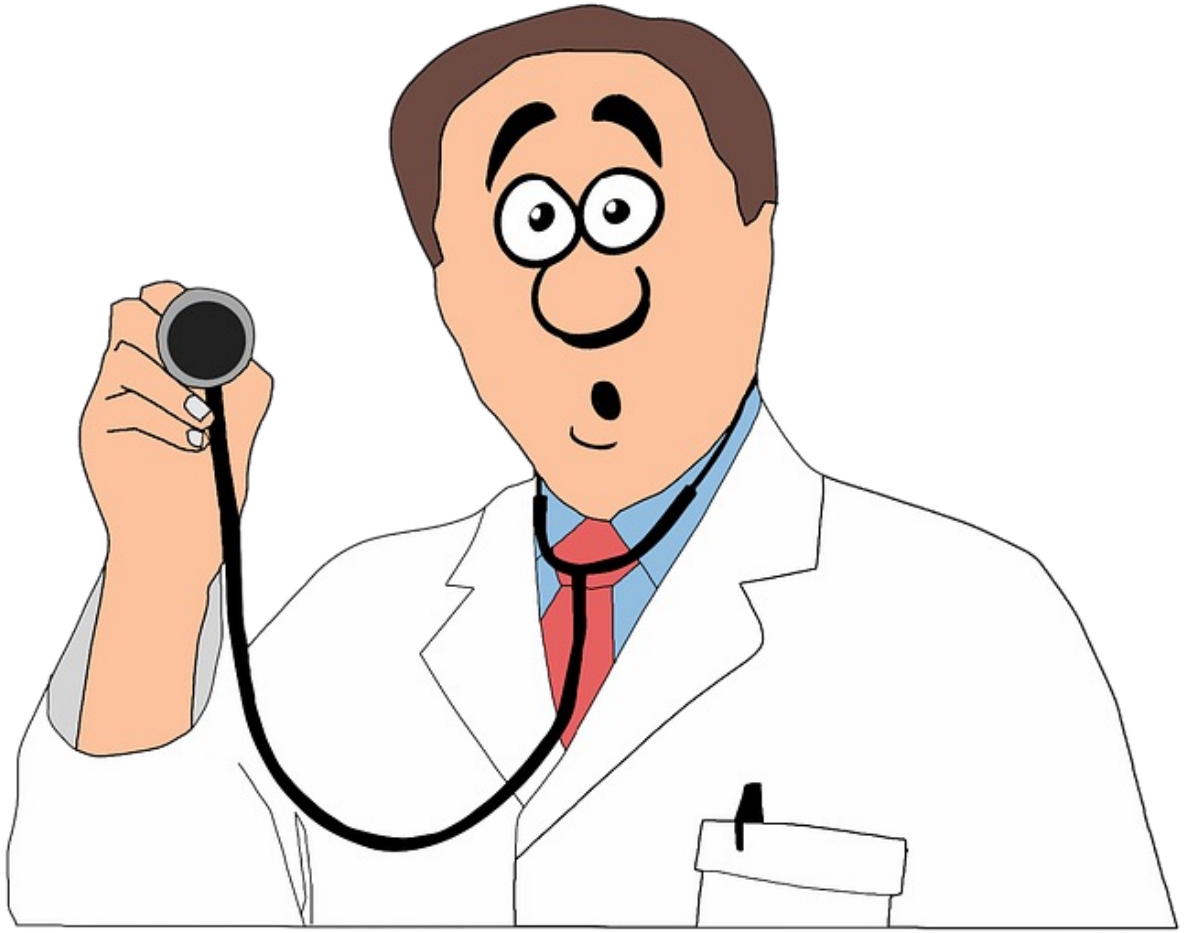
- **K: number of failures**
- **R: number of successes**

$$f(k;r,p) \equiv \Pr(X = k) = \binom{k+r-1}{k} p^r (1-p)^k$$

SSI Risk Factors

- Diabetes
- BMI
- Nicotine Use
- Gender
- Operation Duration
- Wound Class
- Nasal carriage of Staphylococcus aureus
- Recent Chemotherapy
- Hyperglycemia

Features	Frequency
Diabetes	5
Body mass index (obesity)	5
Smoking/Nicotine Use	5
American Society of Anesthesiologists' (ASA) physical classification score	5
Gender (Male)	4
Older age	3
Steroid use	3
Operation Duration	3
Recent major surgical procedure	3
Wound class (NNIS)	3
preoperative serum glucose level of >125 mg/dL	2
two or more surgical residents participating in the operative procedure	2
Nasal carriage of Staphylococcus aureus	2
Renal disease	2
Malignancy/chemotherapy	2
Hyperglycemia	2
Excessive alcohol use	2
Low hemoglobin (≤10g/dL)	2
Low albumin (≤3.4mg/dL)	2



Prevention

CLABSI's Strategies

Educate healthcare personnel regarding the indications for intravascular catheter use, insertion and maintenance

Use maximal sterile barrier precautions, including the use of a cap, mask, sterile gown, sterile gloves, and a sterile full body drape

Hand hygiene should be performed before and after palpating catheter insertion sites as well as before and after inserting, replacing, accessing, repairing, or dressing an intravascular catheter

Assure providers adhere to recommended hygienic practices at all times

Removing catheters when they are no longer needed

CLABSI Checklist

Type	Procedure
Insertion	Practitioner notification to nurse
	Nonsterile assistant must be present
	Central line cart in ICUs
	Hand Hygiene and sterile gloves
	2% chlorhexidine and 70% isopropyl alcohol site prep
	After prep change gloves and repeat hand hygiene
	Sterile gowns and gloves, masks and caps
	Small sterile fenestrated drape over site
	Large sterile drape covers patient's head to toes
	Ultrasonographic guidance when possible
	After insertion, remove drape and gloves
	Repeat hand hygiene and don sterile gloves
	Re-prep site as above
Maintenance	Assess and document necessity daily
	Remove within 24 hours if inserted in emergent setting
	Remove promptly if not needed
	Remove if suspected to be source of infection
	Examine dressing and site every shitf
	Change dressing weekly
	Cap with alcohol-impregnated caps when not in use
	Clean hub with alcohol every time accessed
	Documentation using flowsheets

SSI's Strategies

Full-body bathe before surgery

Antimicrobial prophylaxis should be administered

Glycemic control should be implemented

Prevention strategies to decolonize the Staphylococcus aureus carrier

Care measures to maintain normal temperature during and after surgical procedures

Recommendations to address SSIs

Initiatives	Comments
Immunosuppressive medication	Should not be discontinued prior to surgery for the purpose of preventing SSIs
Nutritional Formulas	Should be considered for underweight patients
Bathing before surgery	Is a good clinical practice
Intranasal mupirocin	Applications of muriprocin 2% ointment for patients with known nasal carriage of S. aureus u
Warming Devices	Should be used in the operating room and during the surgical procedure for patient body warming
Blood Glucose Control	Protocols for intensive perioperative blood glucose control should be used for both diabetic and non-diabetic adult patients
Wound Protectors	Should be considered in clean-contaminated, contaminated and dirty abdominal surgical procedures for the purpose of reducing the rate of SSI.
Antibiotics	Preoperative oral antibiotics combined with MBP should be used to reduce the risk of SSI in adult patients undergoing elective colorectal surgery.

CLABSI AND SSI Initiatives

CLABSI: Institute for Healthcare Improvement

1. Hands hygiene
2. Assessment of the condition of the addressing and change if necessary
3. USE of aseptic technique to access and change the catheter device
4. Standardize catheter change
5. Daily check of the venous line and removal of unnecessary lines

SSI: World Health Organization (WHO)

1. To provide comprehensive evidence- and expert consensus-based recommendations to be applied during the pre-, intra- and postoperative periods for prevention of SSI and to help combat antimicrobial resistance (AMR).
2. To support health (and related) settings and practitioners to develop or strengthen infection prevention and control (IPC) programs, with a focus on surgical safety, as well as AMR action plans.
3. To highlight that working as teams, both practices and patient outcomes can be improved, taking account of resource availability.

Prioritization of design solutions

- No prioritization
- compare the solutions or initiatives between healthcare authors and healthcare agencies and governmental programs:

Centers for Disease Control and Prevention) and national bibliography

Solutions
(CLABSI)/(SSI)
Using Literature Review And validated using government programs

Implementation

- Implementation in progress (COVID-19)
- Submit our recommendations to our industry partner
- Schedule a meeting with the hospital
- Ask for feedback

Conclusions: What we learned

Medical terminology and procedures

Logistic and Negative binomial regression for data analysis

Research is always the first thing to do!

Engineering is the process of making research-based data driven decisions, applying creativity, and looking at the details.

We do not live in a perfect world

Practice data backup every time

Effort and hard work will always help you to be on track

Q + A

References

Bastian, N. D., Kang, H., Nembhard, H. B., Bloschichak, A., & Griffin, P. M. (2016). The impact of a pay-for-performance program on central line–associated blood stream infections in Pennsylvania. *Hospital topics*, *94*(1), 8-14.

Parreco, J. P., Hidalgo, A. E., Badilla, A. D., Ilyas, O., & Rattan, R. (2018). Predicting central line-associated bloodstream infections and mortality using supervised machine learning. Journal of critical care, 45, 156-162.

ASA Physical Status Classification System. (n.d.). Retrieved April 7, 2020, from https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system

Boston University School of Public Health. Simple Linear Regression. (2016, January 6). Retrieved April 4, 2020, from http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/R/R5_Correlation-Regression/R5_Correlation-Regression4.html

Yang, S. Berdine, G. Negative Binomial Regression. (2015, April 7). Retrieved April 4, 2020 from https://pdfs.semanticscholar.org/38ac/f9647578aa224d621da220eb6de3543f6be3.pdf

Highmark Medical Services. 2007. Quality Blue: A Physician Pay for Performance System. https://www.highmarkblue-shield.com/pdf_file/qualityblue-program-manual.pdf

Ward, M. M., Clabaugh, G., Evans, T. C., & Herwaldt, L. (2012). A Successful, Voluntary, Multicomponent Statewide Effort to Reduce Health Care–Associated Infections. *American Journal of Medical Quality*, *27*(1), 66–73. https://doi.org/10.1177/1062860611405506

Patel PK, Gupta A, Vaughn VM, et al. Review of Strategies to Reduce Central Line-Associated Bloodstream Infection (CLABSI) and Catheter-Associated Urinary Tract Infection (CAUTI) in Adult ICUs. Journal of Hospital Medicine. 2018 Feb;13(2):105-116. DOI: 10.12788/jhm.2856

HAI and Antibiotic Use Prevalence Survey. (2014, March 26). Retrieved from https://www.cdc.gov/hai/eip/antibiotic-use.html

Our History: Hospitals of Providence: El Paso, TX. (n.d.). Retrieved from https://www.thehospitalsofprovidence.com/about-us/our-history

https://www.medicare.gov/hospitalcompare/profile.html#vwgrph=0&profTab=3&ID=450002&loc=EL%20PASO%2C%20TX&lat=31.7587198&lng=-106.4869314&name=THE%20HOSPITALS%20OF%20PROVIDENCE%20MEMORIAL%20CAMPUS&Distn=1.3

http://leanmanufacturingtools.org/494/poka-yoke/

https://www.sciencedirect.com/topics/medicine-and-dentistry/logistic-regression-analysis

https://data.library.virginia.edu/getting-started-with-negative-binomial-regression-modeling/