

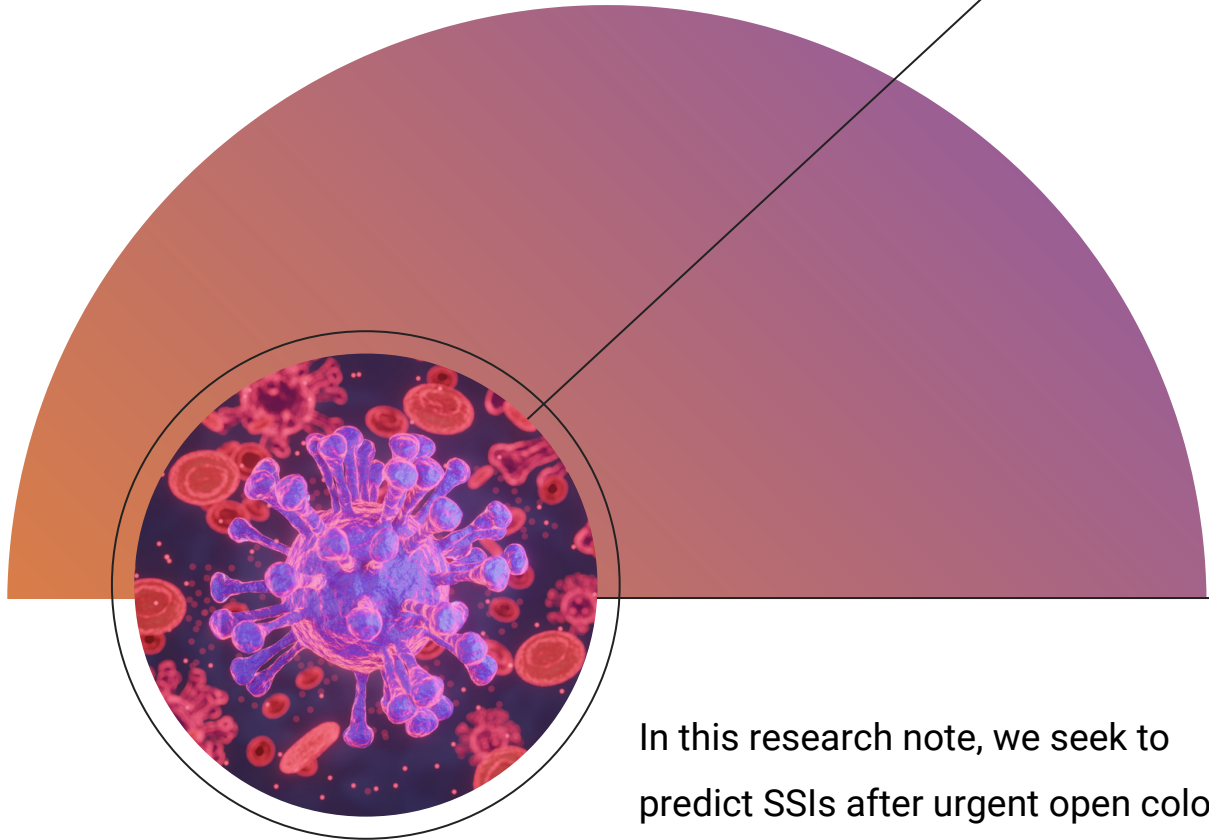
BinDoc Research Note No. 3

Expanding the Sample of Surgical
Site Infections (SSIs) after
Urgent/Elective Open Colon
Surgeries in Germany 2019-2021
based on an xgboost ML Model
E.B.

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Goal



In this research note, we seek to predict SSIs after urgent open colon surgeries with an xgboost Machine Learning (ML) model based on the five characteristics surgical wound toilet (OPS-Code 5-896.1b), temporary soft tissue coverage (OPS-Code 5-916.a), excision (OPS-Codes 5-894, 5-895), gangrene (ICD-10 R02), and peritonitis (ICD-10 K65); we thereby expand our prior definition based on ICD-10 codes to get a more realistic sample of SSIs.

ABSTRACT

In Research Note No. 1, we used ICD-10 codes T81.4, T80.2, T83.5, T87.4, T82.6, T82.7, T84.5, T84.6, T84.7, and O86.0 to define Surgical Site Infections (SSIs) and determined the SSI-rate in C-sections and colon surgeries like in Aghdassi et al. (2021).

Notably, we tracked a patient for 30 days following the dismissal after the first stay that comprised a C-section or a colon surgery to determine whether the patient developed an SSI. In Research Note No. 2, we looked at urgent/elective[1] open colon surgeries and displayed patient characteristics, treatments, and outcomes differentiating between non-SSI and SSI-cases.

We found that, generally, SSI-cases display more comorbidities, adverse events, and special treatments than non-SSI cases, as expected.

Surprisingly, however, in urgent cases, the death rate was substantially lower for SSI-patients compared to non-SSI patients. One reason might be that we overlooked SSI-cases by focusing exclusively on the above ICD-10 codes. Some SSI-cases, however, might have been left uncoded, although the patients were treated according to an SSI.

In this research note, we thus seek to predict SSIs after urgent open colon surgeries from 2019 to 2021 with an xgboost Machine Learning model based on five characteristics: surgical wound toilet (any time), soft tissue coverage (any time), excision (any time), gangrene (SD during first stay, MD/SD thereafter), and peritonitis (SD during first stay, MD/SD thereafter), assuming that the five characteristics are indicative for SSIs (leaving aside relaparotomy and nosocomial sepsis, as there might be other conditions leading to these two events, especially in urgent cases). We thus construct a new SSI variable, SSINEW, which comprises both the cases based on the above ICD-10 codes and the cases which are predicted by the xgboost model. We report the incidence based on the new definition, and the death rates and several other characteristics for non-SSINEW and SSINEW cases.

After running the xgboost ML model with the prior SSI variable (based on the above ICD-10 codes) as the dependent variable, and surgical wound toilet, soft tissue coverage, excision, gangrene, and peritonitis as predictors, we report the confusion matrix for the test set (25% of the data) in Figure 1.

The confusion matrix shows that 30 out of 84 SSIs are correctly predicted by the five predictors (sensitivity of 36%), and that 47 SSIs are predicted, although there were none (false positives).

We now assume that these false positives are uncoded SSI infections and add them to the other SSI cases, and we construct a new dummy variable (SSINEW) for all patients in our dataset comprising both the SSIs based on the above four ICD-10 codes and the SSIs predicted by the model (SSINEW=1 with N=527). With this new definition of SSIs, we again compare non-SSI and SSI cases in terms of patient characteristics, treatments, and outcomes (like in Research Note 2).

Using SSINEW, we find that the SSI-rate in urgent open colon surgeries increases by about 64 percent to 14.7 per 100 cases (prior 9.4). Most notably, while the death rate of patients with SSIs based on the previous definition was surprisingly low, it now increases to 14.8%, thereby surpassing the rate of the non-SSINEW group with 11.9% ($p=0.066$).

Thus, the new and wider definition of SSIs seems to provide a more realistic picture of mortality. Moreover, most of the other previous findings tend to get stronger with the new conceptualization of SSIs. While these findings are promising, they are still experimental, and it is crucial to evaluate an SSI definition based on ICD-10 codes and ML models with individual data from patients' health records.

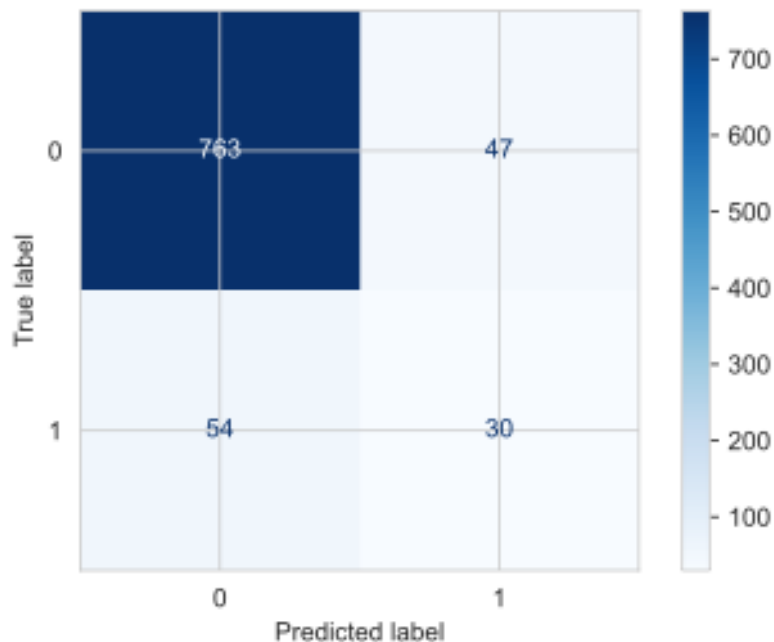


Figure 1. Confusing Matrix for the Test Set (25% of the data)

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
age group	15.2 (3.3)	15.0 (3.1)	0.10
female	1577 (51.74)	270 (51.23%)	0.8
adipositas	238 (7.81%)	69 (13.09%)	<0.001
main diagnosis K57 (diverticular disease of intestine)	668 (21.92%)	106 (20.11%)	0.4
main diagnosis C18 (malignant neoplasm of colon)	1091 (35.79%)	150 (28.46%)	0.001
main diagnosis D12 (benign neoplasm of colon)	30 (0.98%)	4 (0.76%)	0.6
main diagnosis K63.1 (perforation of intestine, non-traumatic)	116 (3.81%)	45 (8.54%)	<0.001

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

COMORBIDITIES CHARLSON INDEX

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Myocardial infarction (mi)	104 (3.41%)	23 (4.36%)	0.3
Congestive heart failure (chf)	366 (12.01%)	97 (18.41%)	<0.001
Peripheral vascular disease (pvd)	263 (8.63%)	57 (10.82%)	0.10
Cerebrovascular disease (cevd)	104 (3.41%)	33 (6.26%)	0.002
Dementia	150 (4.92%)	20 (3.80%)	0.3
Chronic pulmonary disease (cpd)	271 (8.89%)	63 (11.95%)	0.026
Rheumatic disease (rheumd)	41 (1.35%)	11 (2.09%)	0.2
Peptic ulcer disease (pud)	46 (1.51%)	12 (2.28%)	0.2

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
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COMORBIDITIES CHARLSON INDEX

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Liver disease, mild (mld)	144 (4.72%)	20 (3.80%)	0.3
Diabetes w/o chronic compl. (diab)	416 (13.65%)	84 (15.94%)	0.2
Diabetes w chronic compl. (diabwc)	85 (2.79%)	20 (3.80%)	0.2
Hemiplegia/paraplegia (hp)	74 (2.43%)	23 (4.36%)	0.012
Renal disease (rend)	440 (14.44%)	106 (20.11%)	<0.001
Any malignancy (canc)	500 (16.40%)	89 (16.89%)	0.8
Liver disease, mod/severe (msld)	25 (0.82%)	4 (0.76%)	>0.9
Metastatic solid tumor (metacanc)	612 (20.08%)	102 (19.35%)	0.7

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COMORBIDITIES CHARLSON INDEX

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Aids	2 (0.07%)	1 (0.19%)	0.4
Charlson Score	2.32 (2.97)	2.52 (2.92)	0.012
Alcohol (F10, K70, G62.1)	56 (1.84%)	13 (2.47%)	0.3
Nutrition (E12, E43:E46)	179 (5.87%)	61 (11.57%)	<0.001

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

IN-STAY TREATMENT OR ADVERSE EVENTS, PLUS OUTCOMES

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Chemotherapy (first stay)	31 (1.02%)	6 (1.14%)	0.8
Blood Transfusion 1TE to <6TE	752 (24.67%)	182 (34.54%)	<0.001
Blood Transfusion >6TE	116 (3.81%)	42 (7.97%)	<0.001
Anastomotic leakage (K91.83)	90 (2.95%)	88 (16.70%)	<0.001
Time to Surgery	117 (161)	131 (202)	0.4
Enterostoma/Blind Closure	693 (22.74%)	194 (36.81%)	<0.001
Catheter (8-831)	1020 (33.46%)	229 (43.45%)	<0.001
Intravenous Anaesthesia (8- 900)	83 (2.72%)	14 (2.66%)	>0.9

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

IN-STAY TREATMENT OR ADVERSE EVENTS, PLUS OUTCOMES

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Manip. Urinary Tract (8-132)	24 (0.79%)	10 (1.90%)	0.015
Respiration Hours none or missing	2299 (75.43%)	353 (66.98%)	<0.001
Respiration Hours	38 (78)	122 (286)	<0.001
Enteral/parenteral nutrition (8-015/-016/-017/-018)	31 (1.02%)	10 (1.90%)	0.080
Lap: Relaparatomie (5-541.2)	140 (4.59%)	117 (22.20%)	<0.001
Colon: Adhesiolysis (5-469.20)	526 (17.26%)	161 (30.55%)	<0.001
Complex Treatment (8-98f)	674 (22.11%)	214 (40.61%)	<0.001
Geriatric Complex (8-550)	86 (2.82%)	27 (5.12%)	0.005

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES
IN-STAY TREATMENT OR ADVERSE EVENTS, PLUS OUTCOMES**

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
LOS ICU	2.1 (3.5)	5.3 (9.4)	<0.001
Ileus (ICD-10 K56)	873 (28.64%)	182 (34.54%)	0.006
Nosocomial UTI	286 (9.38%)	96 (18.22%)	<0.001
Nosocomial Pneumonia	127 (4.17%)	75 (14.23%)	<0.001
Nosocomial Sepsis	195 (6.40%)	108 (20.49%)	<0.001
Death	364 (11.94%)	78 (14.80%)	0.066
Regular Dismissal	2055 (67.42%)	282 (53.51%)	<0.001
Transferral Other Hospital	134 (4.40%)	46 (8.73%)	<0.001

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

CLINIC CHARACTERISTICS

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Clinic type public	1379 (45.24%)	293 (55.60%)	<0.001
Clinic type nonprofit	973 (31.92%)	128 (24.29%)	<0.001
Clinic type private	696 (22.83%)	106 (20.11%)	0.2
<199 beds	248 (8.14%)	43 (8.16%)	>0.9
200-599 beds	2041 (66.96%)	339 (64.33%)	0.2
600-999 beds	495 (16.24%)	77 (14.61%)	0.3
1000+ beds	246 (8.07%)	68 (12.90%)	<0.001

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

COMORBIDITIES ELIXHAUSER INDEX

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Congestive heart failure (chf)	357 (11.71%)	95 (18.03%)	<0.001
Cardiac Arrythmias (carit)	652 (21.39%)	156 (29.60%)	<0.001
Valvular Disease (valv)	124 (4.07%)	37 (7.02%)	0.003
Pulm Circulation Disorders (pcd)	67 (2.20%)	27 (5.12%)	<0.001
Peripheral Vasc. Disorders (pvd)	263 (8.63%)	57 (10.82%)	0.10
Hypertension, uncompl (hypunc)	1454 (47.70%)	266 (50.47%)	0.2
Hypertension, compl (hypc)	87 (2.85%)	20 (3.80%)	0.2
Paralysis (para)	74 (2.43%)	23 (4.36%)	0.012

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

COMORBIDITIES ELIXHAUSER INDEX

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Other Neurological Disorders (ond)	143 (4.69%)	23 (4.36%)	0.7
Chronic Pulmonary Disease (cpd)	271 (8.89%)	63 (11.95%)	0.026
Diabetes, uncomplicated (diabunc)	397 (13.02%)	77 (14.61%)	0.3
Diabetes, complicated (diabc)	105 (3.44%)	26 (4.93%)	0.093
Hypothyroidism (hypothy)	441 (14.47%)	92 (17.46%)	0.075
Renal Failure (rf)	440 (14.44%)	106 (20.11%)	<0.001
Liver Disease (ld)	178 (5.84%)	26 (4.93%)	0.4
Peptic Ulcer D, excl bleeding (pud)	9 (0.30%)	4 (0.76%)	0.11

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

COMORBIDITIES ELIXHAUSER INDEX

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Aids (aids)	2 (0.07%)	1 (0.19%)	0.4
Lymphoma (lymph)	14 (0.46%)	3 (0.57%)	0.7
Metastatic Cancer (metacanc)	612 (20.08%)	102 (19.35%)	0.7
Solid Tumor wo Metast (solidtum)	484 (15.88%)	85 (16.13%)	0.9
Rheumatoid arthritis (rheumd)	44 (1.44%)	10 (1.90%)	0.4
Coagulopathy (coag)	379 (12.43%)	120 (22.77%)	<0.001
Obesity (obes)	238 (7.81%)	69 (13.09%)	<0.001
Weight Loss (wloss)	246 (8.07%)	73 (13.85%)	<0.001

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AFTER URGENT OPEN COLON SURGERIES**

COMORBIDITIES ELIXHAUSER INDEX

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Fluid&Electrolyte Disorders (fed)	1639 (53.77%)	377 (71.54%)	<0.001
Blood loss anemia (blane)	88 (2.89%)	11 (2.09%)	0.3
Deficiency Anemia (dane)	168 (5.51%)	44 (8.35%)	0.011
Alcohol abuse (alcohol)	56 (1.84%)	13 (2.47%)	0.3
Drug abuse (drug)	17 (0.56%)	4 (0.76%)	0.5
Psychoses (psycho)	22 (0.72%)	5 (0.95%)	0.6
Depression (depre)	157 (5.15%)	43 (8.16%)	0.006
CCIElixScore	12 (14)	15 (15)	<0.001

**TABLE 1. DIFFERENCES OF NON-SSINEW AND SSINEW PATIENTS
AFTER URGENT OPEN COLON SURGERIES**

INDICATORS FOR SSIS

Parameters	Urgent Non-SSINEW N=3048	Urgent SSI Urgent SSINEW N=527	p-value
Temp Soft Tissue Coverage (5-916.a)	94 (3.08%)	320 (60.72%)	<0.001
Surg. Wound Toilet, Belly (5- 896.1b)	0 (0%)	152 (28.84%)	<0.001
Excision (5-894, 5-895)	33 (1.08%)	23 (4.36%)	<0.001
Gangrene (R02)	9 (0.30%)	7 (1.33%)	0.005
Peritonitis (K65)	687 (22.54%)	303 (57.50%)	<0.001

1] Whether a case is urgent/elective, is determined by the admission reason, and open colon surgeries are defined via the following OPS-Codes:

"5-455.01","5-455.02","5-455.03","5-455.04","5-455.07", "5-455.11","5-455.12","5-455.13","5-455.14","5-455.17", "5-455.21","5-455.22","5-455.23","5-455.24","5-455.27", "5-455.31","5-455.32","5-455.33","5-455.34","5-455.37", "5-455.41","5-455.42","5-455.43","5-455.44","5-455.47", "5-455.51","5-455.52","5-455.53","5-455.54","5-455.57", "5-455.61","5-455.62","5-455.63","5-455.64","5-455.67", "5-455.71","5-455.72","5-455.73","5-455.74","5-455.77", "5-455.91","5-455.92","5-455.93","5-455.94","5-455.97", "5-455.a1","5-455.a2","5-455.a3","5-455.a4","5-455.a7", "5-455.b1","5-455.b2","5-455.b3","5-455.b4","5-455.b7", "5-455.c1","5-455.c2","5-455.c3","5-455.c4","5-455.c7", "5-455.d1","5-455.d2","5-455.d3","5-455.d4","5-455.d7", "5-456.00","5-456.01","5-456.02","5-456.03","5-456.04","5-456.08".