

## Course Project

### Overview

For the course project, we will investigate the problem of predicting readmission of hospital patients. Readmission of patients following discharge from the hospital places an enormous and very expensive burden on the US healthcare system (estimated at \$40B in 2011) [1].

Each of you will be working on developing a data science solution for this problem individually.

In real life, a large part of the role of a data scientist is to map a vague business problem into one or more concrete data science tasks, but for the sake of this project, we will start with a well-defined problem. But you still have a number of things to do as a budding data scientist, for example:

- **Exploring and sanitizing the data**
  - a. The dataset may have duplicates, missing values and other data quality issues that may need to be addressed.
  - b. The class variable may need to be derived in some manner.
  - c. You would also need to understand the different attributes, understand their distribution, and correlation with the class or value you are trying to predict
- **Preprocessing the data**
  - a. Depending on the classification technique, some attribute types may need to be mapped to others
  - b. Some features may need to be transformed to improve performance
- **Feature selection**
  - a. Depending on the classification technique, you may want to select a subset of features based on your exploratory analysis
  - b. You may also want to use domain knowledge to select or construct appropriate features
- **Building models and evaluating techniques**
  - a. You would need to ensure that you are training, tuning hyperparameters of, and rigorously evaluating your chosen method
  - b. You may need to try out multiple methods and rigorously compare them.

These steps are not always sequential, and you may need to go back and revisit previous steps as you refine your solution.

The objective of the course project is to give you an opportunity to demonstrate your understanding of these stages. This is a foundational course, so you are not expected to know highly advanced techniques, but rather the basic concepts and process that we have covered in this course, and how to put them together.

### Dataset

We will use this [UCI dataset](#) for our project. The dataset (diabetic\_data.csv) represents 10 years (1999-2008) of clinical care at 130 US hospitals and integrated delivery networks. It includes over 50 features representing patient and hospital outcomes. Information was extracted from the database for encounters that satisfied the following criteria.

- (1) It is an inpatient encounter (a hospital admission).
- (2) It is a diabetic encounter, that is, one during which any kind of diabetes was entered into the system as a diagnosis.
- (3) The length of stay was at least 1 day and at most 14 days.
- (4) Laboratory tests were performed during the encounter.
- (5) Medications were administered during the encounter.

The data contains such attributes as patient number, race, gender, age, admission type, time in hospital, medical specialty of admitting physician, number of lab test performed, HbA1c test result, diagnosis, number of medications, diabetic medications, number of outpatient, inpatient, and emergency visits in the year before the hospitalization, etc. Some of these are encoded as numeric codes whose meanings are described in a separate file (IDs\_mapping.csv) that is part of the download.

The class variable readmitted indicates whether the encounter is not a readmission case (54864 samples), represents a readmission more than 30 days post discharge (35545 samples), or a readmission within 30 days of discharge (11357 samples). More information about how the dataset was created may be found in this research article.

The objective of predictive analysis is to build a binary classification model that can predict early (<30 days) readmission given the patient's features.

The dataset will be split into a training and test set using stratified sampling to ensure that the proportions of the three classes are similar between the training and test sets. You can download the train and test sets from this folder.

The test set may only be used for final evaluation of models, by computing classification accuracy and plotting AUC curves. It may not be used to modify the models being evaluated in any way.

## **Submission**

The expected outcomes of the project are:

A well-documented Python notebook indicating the different steps in the workflow, with explanations of what was the outcome of each step, what decisions were made etc. The last step of the workflow should be the evaluation of one or more trained models on the test set.

A presentation to explain how you went about solving the problem, interesting insights or approaches tried, and the results you obtained.

### **Grading:**

Scoring is based on Basics (10) + EDA (20) + Preprocessing/FE (20) + Modeling/Tuning (20) + Evaluation (20) + Readability (10) = 100

Project presentations:

Each presentation should be 5 minutes in length with 3 to 4 slides that include the content specified below.

- Describe your main analysis strategy – pre-processing steps, choice of models, parameters, failures
- Describe your main findings – model and analysis.
- Draw conclusions with explanations, citing evidence from your model performance.

Submit the link to your presentation as part of your project submission.

Total Grade = 80(code+report) + 20(Presentation).

### **References**

There is a lot of literature about the problem of readmissions and important predictors, these are just a couple of links to get you started:

[1] 3 Strategies to Address the \$40B Hospital Readmission Problem, currenthealth.com [\[link\]](#)

[2] Hospital Readmissions as a Measure of Quality of Health Care, Advantages and Limitations. Archives of JAMA Internal Medicine [\[link\]](#)

### **Dataset Attributes:**

TABLE 1: List of features and their descriptions in the initial dataset (the dataset is also available at the website of Data Mining and Biomedical Informatics Lab at VCU (<http://www.cioslab.vcu.edu/>)).

Feature name	Type	Description and values	% missing
Encounter ID	Numeric	Unique identifier of an encounter	0%
Patient number	Numeric	Unique identifier of a patient	0%
Race	Nominal	Values: Caucasian, Asian, African American, Hispanic, and other	2%
Gender	Nominal	Values: male, female, and unknown/invalid	0%
Age	Nominal	Grouped in 10-year intervals: [0, 10), [10, 20), . . . , [90, 100)	0%
Weight	Numeric	Weight in pounds.	97%
Admission type	Nominal	Integer identifier corresponding to 9 distinct values, for example, emergency, urgent, elective, newborn, and not available	0%
Discharge disposition	Nominal	Integer identifier corresponding to 29 distinct values, for example, discharged to home, expired, and not available	0%
Admission source	Nominal	Integer identifier corresponding to 21 distinct values, for example, physician referral, emergency room, and transfer from a hospital	0%
Time in hospital	Numeric	Integer number of days between admission and discharge	0%
Payer code	Nominal	Integer identifier corresponding to 23 distinct values, for example, Blue Cross\Blue Shield, Medicare, and self-pay	52%
Medical specialty	Nominal	Integer identifier of a specialty of the admitting physician, corresponding to 84 distinct values, for example, cardiology, internal medicine, family\general practice, and surgeon	53%
Number of lab procedures	Numeric	Number of lab tests performed during the encounter	0%
Number of procedures	Numeric	Number of procedures (other than lab tests) performed during the encounter	0%
Number of medications	Numeric	Number of distinct generic names administered during the encounter	0%
Number of outpatient visits	Numeric	Number of outpatient visits of the patient in the year preceding the encounter	0%
Number of emergency visits	Numeric	Number of emergency visits of the patient in the year preceding the encounter	0%
Number of inpatient visits	Numeric	Number of inpatient visits of the patient in the year preceding the encounter	0%
Diagnosis 1	Nominal	The primary diagnosis (coded as first three digits of ICD9); 848 distinct values	0%
Diagnosis 2	Nominal	Secondary diagnosis (coded as first three digits of ICD9); 923 distinct values	0%
Diagnosis 3	Nominal	Additional secondary diagnosis (coded as first three digits of ICD9); 954 distinct values	1%
Number of diagnoses	Numeric	Number of diagnoses entered to the system	0%
Glucose serum test result	Nominal	Indicates the range of the result or if the test was not taken. Values: ">200," ">300," "normal," and "none" if not measured	0%
A1c test result	Nominal	Indicates the range of the result or if the test was not taken. Values: ">8" if the result was greater than 8%, ">7" if the result was greater than 7% but less than 8%, "normal" if the result was less than 7%, and "none" if not measured.	0%
Change of medications	Nominal	Indicates if there was a change in diabetic medications (either dosage or generic name). Values: "change" and "no change"	0%
Diabetes medications	Nominal	Indicates if there was any diabetic medication prescribed. Values: "yes" and "no"	0%
24 features for medications	Nominal	For the generic names: metformin, repaglinide, nateglinide, chlorpropamide, glimepiride, acetohexamide, glipizide, glyburide, tolbutamide, pioglitazone, rosiglitazone, acarbose, miglitol, troglitazone, tolazamide, examide, sitagliptin, insulin, glyburide-metformin, glipizide-metformin, glimepiride-pioglitazone, metformin-rosiglitazone, and metformin-pioglitazone, the feature indicates whether the drug was prescribed or there was a change in the dosage. Values: "up" if the dosage was increased during the encounter, "down" if the dosage was decreased, "steady" if the dosage did not change, and "no" if the drug was not prescribed	0%
Readmitted	Nominal	Days to inpatient readmission. Values: "<30" if the patient was readmitted in less than 30 days, ">30" if the patient was readmitted in more than 30 days, and "No" for no record of readmission.	0%

## Categorical Attributes and Values

**Race**

1. Caucasian
2. Asian
3. AfricanAmerican
4. Hispanic
5. Other

**Gender**

1. Male
2. Female
3. Unknown/Invalid

**Age**

1. [0-10)
2. [10-20)
3. [20-30)
4. [30-40)
5. [40-50)
6. [50-60)
7. [60-70)
8. [70-80)
9. [80-90)
10. [90-100)

**Weight**

1. [0-25)
2. [25-50)
3. [50-75)
4. [75-100)
5. [100-125)
6. [125-150)
7. [150-175)
8. [175-200)
9. >200

**Admission Type ID (from IDs\_mapping.csv)**

1	Emergency
2	Urgent
3	Elective
4	Newborn
5	Not Available
6	NULL
7	Trauma Center
8	Not Mapped

**Discharge Disposition ID (from IDs\_mapping.csv)**

discharge_disposition_id	description
1	Discharged to home
2	Discharged/transferred to another short term hospital
3	Discharged/transferred to SNF
4	Discharged/transferred to ICF
5	Discharged/transferred to another type of inpatient care institution
6	Discharged/transferred to home with home health service
7	Left AMA
8	Discharged/transferred to home under care of Home IV provider
9	Admitted as an inpatient to this hospital
10	Neonate discharged to another hospital for neonatal aftercare
11	Expired
12	Still patient or expected to return for outpatient services
13	Hospice / home
14	Hospice / medical facility
15	Discharged/transferred within this institution to Medicare approved swing bed
16	Discharged/transferred/referred another institution for outpatient services
17	Discharged/transferred/referred to this institution for outpatient services
18	NULL
19	Expired at home. Medicaid only, hospice.
20	Expired in a medical facility. Medicaid only, hospice.
21	Expired, place unknown. Medicaid only, hospice.
22	Discharged/transferred to another rehab fac including rehab units of a hospital .
23	Discharged/transferred to a long term care hospital.
24	Discharged/transferred to a nursing facility certified under Medicaid but not certified under Medicare.
25	Not Mapped
26	Unknown/Invalid
30	Discharged/transferred to another Type of Health Care Institution not Defined Elsewhere
27	Discharged/transferred to a federal health care facility.
28	Discharged/transferred/referred to a psychiatric hospital of psychiatric distinct part unit of a hospital
29	Discharged/transferred to a Critical Access Hospital (CAH).

**Discharge Source ID (from IDs\_mapping.csv)**

admission_source_id	description
1	Physician Referral

2	Clinic Referral
3	HMO Referral
4	Transfer from a hospital
5	Transfer from a Skilled Nursing Facility (SNF)
6	Transfer from another health care facility
7	Emergency Room
8	Court/Law Enforcement
9	Not Available
10	Transfer from critical access hospital
11	Normal Delivery
12	Premature Delivery
13	Sick Baby
14	Extramural Birth
15	Not Available
17	NULL
18	Transfer From Another Home Health Agency
19	Readmission to Same Home Health Agency
20	Not Mapped
21	Unknown/Invalid
22	Transfer from hospital inpt/same fac reslt in a sep claim
23	Born inside this hospital
24	Born outside this hospital
25	Transfer from Ambulatory Surgery Center
26	Transfer from Hospice

### Payer Code

(the dataset documentation refers to 23 codes, following are the ones in the dataset)

1. BC
2. CH
3. CM
4. CP
5. DM
6. FR
7. HM
8. MC
9. MD
10. MP
11. OG
12. OT



13. PO
14. SI
15. SP
16. UN
17. WC

### **Medical Speciality**

1. AllergyandImmunology
2. Anesthesiology
3. Anesthesiology-Pediatric
4. Cardiology
5. Cardiology-Pediatric
6. DCPTEAM
7. Dentistry
8. Dermatology
9. Emergency/Trauma
10. Endocrinology
11. Endocrinology-Metabolism
12. Family/GeneralPractice
13. Gastroenterology
14. Gynecology
15. Hematology
16. Hematology/Oncology
17. Hospitalist
18. InfectiousDiseases
19. InternalMedicine
20. Nephrology
21. Neurology
22. Neurophysiology
23. Obsterics&Gynecology-GynecologicOnco
24. Obstetrics
25. ObstetricsandGynecology
26. Oncology
27. Ophthalmology
28. Orthopedics
29. Orthopedics-Reconstructive
30. Osteopath
31. Otolaryngology
32. OutreachServices
33. Pathology
34. Pediatrics
35. Pediatrics-AllergyandImmunology
36. Pediatrics-CriticalCare
37. Pediatrics-EmergencyMedicine
38. Pediatrics-Endocrinology
39. Pediatrics-Hematology-Oncology
40. Pediatrics-InfectiousDiseases
41. Pediatrics-Neurology

42. Pediatrics-Pulmonology
43. Perinatology
44. PhysicalMedicineandRehabilitation
45. PhysicianNotFound
46. Podiatry
47. Proctology
48. Psychiatry
49. Psychiatry-Addictive
50. Psychiatry-Child/Adolescent
51. Psychology
52. Pulmonology
53. Radiologist
54. Radiology
55. Resident
56. Rheumatology
57. Speech
58. SportsMedicine
59. Surgeon
60. Surgery-Cardiovascular
61. Surgery-Cardiovascular/Thoracic
62. Surgery-Colon&Rectal
63. Surgery-General
64. Surgery-Maxillofacial
65. Surgery-Neuro
66. Surgery-Pediatric
67. Surgery-Plastic
68. Surgery-PlasticwithinHeadandNeck
69. Surgery-Thoracic
70. Surgery-Vascular
71. SurgicalSpecialty
72. Urology

## Diagnosis 1

For explanations of these codes, see [https://en.wikipedia.org/wiki/List\\_of\\_ICD-9\\_codes](https://en.wikipedia.org/wiki/List_of_ICD-9_codes)

10, 11, 110, 112, 114, 115, 117, 131, 133, 135, 136, 141, 142, 143, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 160, 161, 162, 163, 164, 170, 171, 172, 173, 174, 175, 179, 180, 182, 183, 184, 185, 187, 188, 189, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 207, 208, 210, 211, 212, 214, 215, 216, 217, 218, 219, 220, 223, 225, 226, 227, 228, 229, 23, 230, 233, 235, 236, 237, 238, 239, 240, 241, 242, 244, 245, 246, 250, 250.01, 250.02, 250.03, 250.1, 250.11, 250.12, 250.13, 250.2, 250.21, 250.22, 250.23, 250.3, 250.31, 250.32, 250.33, 250.4, 250.41, 250.42, 250.43, 250.5, 250.51, 250.52, 250.53, 250.6, 250.7, 250.8, 250.81, 250.82, 250.83, 250.9, 250.91, 250.92, 250.93, 251, 252, 253, 255, 261, 262, 263, 266, 27, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 3, 300, 301, 303, 304, 305, 306, 307, 308, 309, 31, 310, 311, 312, 314, 318, 320, 322, 323, 324, 325, 327, 331, 332, 333, 334, 335, 336, 337, 338, 34, 340, 341, 342, 344, 345, 346, 347, 348, 349, 35, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 36, 360, 361, 362, 363, 365, 366, 368, 369, 370, 372, 373, 374, 375, 376, 377, 378, 379, 38, 380, 381, 382, 383, 384, 385, 386, 388, 389, 39, 391, 394, 395, 396, 397, 398, 401, 402, 403, 404, 405, 41, 410, 411, 412, 413, 414, 415, 416, 417, 42, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 440, 441, 442, 443, 444, 445, 446, 447, 448, 451, 452, 453, 454, 455, 456, 457, 458, 459, 461, 462, 463, 464, 465, 466, 47, 470,

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## Diagnosis 2

11, 110, 111, 112, 114, 115, 117, 123, 130, 131, 135, 136, 137, 138, 140, 141, 145, 150, 151, 152, 153, 154, 155, 156, 157, 162, 163, 164, 171, 172, 173, 174, 179, 180, 182, 183, 185, 186, 188, 189, 191, 192, 193, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 208, 211, 212, 214, 215, 217, 218, 220, 223, 225, 226, 227, 228, 232, 233, 235, 238, 239, 240, 241, 242, 244, 245, 246, 250, 250.01, 250.02, 250.03, 250.1, 250.11, 250.12, 250.13, 250.2, 250.21, 250.22, 250.23, 250.3, 250.31, 250.32, 250.33, 250.4, 250.41, 250.42, 250.43, 250.5, 250.51, 250.52, 250.53, 250.6, 250.7, 250.8, 250.81, 250.82, 250.83, 250.9, 250.91, 250.92, 250.93, 251, 252, 253, 255, 256, 258, 259, 260, 261, 262, 263, 266, 268, 269, 27, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 31, 310, 311, 312, 314, 316, 317, 318, 319, 320, 322, 323, 324, 325, 327, 331, 332, 333, 335, 336, 337, 338, 34, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 35, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 362, 364, 365, 366, 368, 369, 372, 373, 374, 376, 377, 378, 379, 38, 380, 381, 382, 383, 386, 388, 389, 394, 395, 396, 397, 398, 40, 401, 402, 403, 404, 405, 41, 410, 411, 412, 413, 414, 415, 416, 42, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 440, 441, 442, 443, 444, 446, 447, 448, 451, 452, 453, 454, 455, 456, 457, 458, 459, 46, 460, 461, 462, 463, 464, 465, 466, 470, 472, 473, 474, 475, 477, 478, 480, 481, 482, 483, 484, 485, 486, 487, 490, 491, 492, 493, 494, 495, 496, 5, 500, 501, 506, 507, 508, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 52, 520, 521, 522, 523, 524, 527, 528, 529, 53, 530, 531, 532, 533, 534, 535, 536, 537, 54, 540, 542, 543, 550, 552, 553, 555, 556, 557, 558, 560, 562, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 583, 584, 585, 586, 588, 590, 591, 592, 593, 594, 595, 596, 598, 599, 600, 601, 602, 603, 604, 605, 607, 608, 610, 611, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 625, 626, 627, 634, 641, 642, 644, 645, 646, 647, 648, 649, 652, 654, 656, 658, 659, 66, 661, 663, 664, 665, 670, 674, 680, 681, 682, 683, 684, 685, 686, 691, 692, 693, 694, 695, 696, 698, 7, 70, 701, 702, 703, 704, 705, 706, 707, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 733, 734, 736, 737, 738, 741, 742, 745, 746, 747, 748, 75, 750, 751, 752, 753, 754, 755, 756, 758, 759, 78, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 79, 790, 791, 792, 793, 794, 795, 796, 797, 799, 8, 800, 801, 802, 805, 806, 807, 808, 810, 811, 812, 813, 814, 815, 816, 820, 821, 822, 823, 824, 825, 826, 831, 832, 833, 836, 837, 840, 842, 843, 844, 845, 846, 847, 850, 851, 852, 853, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 879, 88, 880, 881, 882, 883, 884, 891, 892, 893, 894, 9, 905, 906, 907, 908, 909, 910, 911, 912, 913, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 927, 933, 934, 94, 942, 944, 945, 947, 948, 952, 953,

955, 958, 959, 96, 962, 963, 965, 967, 968, 969, 972, 974, 975, 977, 980, 987, 989, 99, 990, 991, 992, 994, 995, 996, 997, 998, 999, ?, E812, E813, E814, E816, E817, E818, E819, E821, E826, E829, E849, E850, E853, E854, E858, E868, E870, E878, E879, E880, E881, E882, E883, E884, E885, E887, E888, E890, E900, E905, E906, E915, E916, E917, E918, E919, E924, E927, E928, E929, E930, E931, E932, E933, E934, E935, E936, E937, E938, E939, E941, E942, E944, E945, E947, E950, E965, E968, E980, V02, V03, V08, V09, V10, V11, V12, V13, V14, V15, V16, V17, V18, V23, V25, V42, V43, V44, V45, V46, V49, V50, V53, V54, V55, V57, V58, V60, V61, V62, V63, V64, V65, V66, V69, V70, V72, V85, V86

### Diagnosis 3

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### Glucose Serum Test Result

- |         |                  |
|---------|------------------|
| 1. Norm | = Normal         |
| 2. >200 |                  |
| 3. >300 |                  |
| 4. None | = (not measured) |

#### **A1C Test result**

- |         |                  |
|---------|------------------|
| 1. Norm | = Normal         |
| 2. >7   |                  |
| 3. >8   |                  |
| 4. None | = (not measured) |

#### **Diabetes Medications Dosage Changes**

##### **Metformin**

- |           |   |
|-----------|---|
| 1. Down   | = Dosage was decreased during encounter |
| 2. No     | = This medication was not prescribed    |
| 3. Steady | = No change in dosage during encounter  |
| 4. Up     | = Dosage was increased during encounter |

Similarly for these other generic medications:

**Repaglinide**

**Nateglinide**

**Chlorpropamide**

**Glimepiride**

**Acetohexamide**

**Glipizide**

**Glyburide**

**Tolbutamide**

**Pioglitazone**

**Rosiglitazone**

**Acarbose**

**Miglitol**

**Troglitazone**

**Tolazamide**

**Examide**

**Citoglipton**

**Insulin**

**Glyburide-metformin**

**Glipizide-metformin**

**Glimepiride-pioglitazone**

**Metformin-rosiglitazone**

**Metformin-pioglitazone**

#### **Change of Medications**

Ch = Change

No = No change

**Diabetes Medications**

No = No Diabetes medication was prescribed during encounter

Yes = Diabetes medication was prescribed during encounter

**Readmitted**

1. <30

2. >30

3. NO