**Appendices for**

**Title:** A Machine Learning-based Framework to Identify Type 2 Diabetes through Electronic Health Records

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**Appendix A: A list of 110 constructed features**

The constructed 110 features across seven sources are listed in Table A1. For every source, we design specific features covering diagnosis codes (ICD-10 codes E11. \*\*\*), diagnosis notes (positive notes and negative notes as shown in Table A3 of Appendix C), self-report notes (persistent hunger, polyuria, and polydipsia), medications (traditional Chinese medicine and western medicine), plasma glucose test (venous and peripheral) and HbA1C test.

**Table A1.** The constructed 110 features coming from seven sources.

|  |  |  |  |
| --- | --- | --- | --- |
| **Source** | **category** | | **Feature** |
| Demographic information | | | f1: De-identification ID of a subject |
| f2: An integer number representing age |
| f3: Gender |
| Communication report | | Self-reporting note | f4: Number of times a subject reporting body weight loss |
| f5: Number of times a subject reporting persistent hunger |
| f6: Number of times a subject reporting polyuria |
| f7: Number of times a subject reporting polydipsia |
| f8: Number of times a subject reporting prescribed diabetes medicine |
| f9: Number of returning visits for diabetes |
| Diagnosis code | f10: Number of times type 2 diabetes codes were assigned |
| f11: Number of times diabetes codes were assigned, but the type of diabetes is not specified |
| f12: Number of times diabetic retinopathy codes were assigned |
| f13: Number of times diabetic neuropathy codes were assigned |
| f14: Number of times diabetic eye disease codes were assigned |
| f15: Number of times diabetic kidney disease codes were assigned |
| f16: Number of times diabetic cerebral vascular disease codes were assigned |
| f17: Number of times diabetic peripheral circulation disease codes were assigned |
| Diagnosis note | f18: Number of times clinician’s notes containing type 2 diabetes |
| f19: Number of times clinician’s notes containing diabetes but the type was not specified |
| f20: Number of times clinician’s notes containing diabetic retinopathy |
| f21: Number of times clinician’s notes containing diabetic neuropathy |
| f22: Number of times clinician’s notes containing diabetic eye disease |
| f23: Number of times clinician’s notes containing diabetic kidney disease |
| f24: Number of times clinician’s notes containing diabetic cerebral vascular disease |
| f25: Number of times clinician’s notes containing diabetic peripheral circulation disease |
| Outpatient diagnosis record | | Diagnosis code | f26: Number of times type 2 diabetes codes were assigned |
| f27: Number of times diabetes codes were assigned, but the type of diabetes is not specified |
| f28: Number of times diabetic retinopathy codes were assigned |
| f29: Number of times diabetic neuropathy codes were assigned |
| f30: Number of times diabetic eye disease codes were assigned |
| f31: Number of times diabetic kidney disease codes were assigned |
| f32: Number of times diabetic cerebral vascular disease codes were assigned |
| f33: Number of times diabetic peripheral circulation disease codes were assigned |
| Diagnosis note | f34: Number of times clinician’s notes containing type 2 diabetes |
| f35: Number of times clinician’s notes containing diabetes but the type was not specified |
| f36: Number of times clinician’s notes containing diabetic retinopathy |
| f37: Number of times clinician’s notes containing diabetic neuropathy |
| f38: Number of times clinician’s notes containing diabetic eye disease |
| f39: Number of times clinician’s notes containing diabetic kidney disease |
| f40: Number of times clinician’s notes containing diabetic cerebral vascular disease |
| f41: Number of times clinician’s notes containing diabetic peripheral circulation disease |
| Inpatient discharge summary | | Diagnosis note | f42: Number of times summary notes containing type 2 diabetes |
| f43: Number of times summary notes containing diabetes but the type was not specified |
| f44: Number of times summary notes containing diabetic retinopathy |
| f45: Number of times summary notes containing diabetic neuropathy |
| f46: Number of times summary notes containing diabetic eye disease |
| f47: Number of times summary notes containing diabetic kidney disease |
| f48: Number of times summary notes containing diabetic cerebral vascular disease |
| f49: Number of times summary notes containing diabetic peripheral circulation disease |
| Inpatient diagnosis record | | Diagnosis code | f50: Number of times type 2 diabetes codes were assigned |
| f51: Number of times diabetes codes were assigned, but the type of diabetes is not specified |
| f52: Number of times diabetic retinopathy codes were assigned |
| f53: Number of times diabetic neuropathy codes were assigned |
| f54: Number of times diabetic eye disease codes were assigned |
| f55: Number of times diabetic kidney disease codes were assigned |
| f56: Number of times diabetic cerebral vascular disease codes were assigned |
| f57: Number of times diabetic peripheral circulation disease codes were assigned |
| Diagnosis note | f58: Number of times clinician’s notes containing type 2 diabetes |
| f59: Number of times clinician’s notes containing diabetes but the type was not specified |
| f60: Number of times clinician’s notes containing diabetic retinopathy |
| f61: Number of times clinician’s notes containing diabetic neuropathy |
| f62: Number of times clinician’s notes containing diabetic eye disease |
| f63: Number of times clinician’s notes containing diabetic kidney disease |
| f64: Number of times clinician’s notes containing diabetic cerebral vascular disease |
| f65: Number of times summary notes containing diabetic peripheral circulation disease |
| Prescription record | | Medication | f66: Number of prescriptions for oral hypoglycemic |
| f67: Number of prescriptions for insulin |
| f68: Number of prescriptions for Chinese traditional hypoglycemic |
| f69: Number of prescriptions for a mixture of western and Chinese traditional oral hypoglycemic |
| f70: Number of prescriptions for Epalrestat |
| f71: Number of prescriptions for Alpha-glucosidase inhibitor |
| f72: Number of prescriptions for Dipeptidylpeptidase IV(DPP-IV) inhibitors |
| f73: Number of prescriptions for Meglitinides |
| f74: Number of prescriptions for Sulfonylureas |
| f75: Number of prescriptions for Thiazolidinediones |
| f76: Number of prescriptions for Biguanides |
| f77: Number of prescriptions for Incretin Mimetics |
| f78: Number of prescriptions for GLP-1 (glucagon-like peptide 1) mimetics |
| f79: Number of prescriptions for compounds of sulfonylurea and thiazolidinedione |
| f80: Number of prescriptions for compounds of Biguanides and Dipeptidylpeptidase IV(DPP-IV) inhibitors |
| f81: Number of prescriptions for compounds of Biguanides and Sulfonylureas compounds |
| f82: Number of prescriptions for compounds of Biguanides and Thiazolidinediones |
| Laboratory test reports | | Venous plasma glucose test | f83: Number of times for 2-hours plasma glucose tests |
| f84: Number of times for 2-hours plasma glucose tests≥11.1mmol/l (200mg/dl) |
| f85: The maximum value of 2-hours plasma glucose tests |
| f86: The minimum value of 2-hours plasma glucose tests |
| f87: The number of times for fasting plasma glucose tests |
| f88: The number of times for fasting plasma glucose tests ranging from 6.1 to 7.0 mmol/l (110 and 126 mg/dl) |
| f89: The maximum value of fasting plasma glucose tests |
| f90: The minimum value of fasting plasma glucose tests |
| f91: Number of times for random plasma glucose tests |
| f92: Number of times for random plasma glucose tests≥11.1mmol/l (200mg/dl) |
| f93: The maximum value of random plasma glucose tests |
| f94: The minimum value of random plasma glucose tests |
| Peripheral plasma glucose test | f95: Number of times for 2-hours peripheral plasma glucose tests |
| f96: Number of times for 2-hours peripheral plasma glucose tests ≥ 11.1mmol/l (200mg/dl) |
| f97: The maximum value of 2-hours peripheral plasma glucose tests |
| f98: The minimum value of 2-hours peripheral plasma glucose tests |
| f99: Number of times for peripheral fasting plasma glucose tests |
| f100: Number of times for peripheral fasting plasma glucose tests ranging from 6.1 to 7.0 mmol/l (110 and 126 mg/dl) |
| f101: The maximum value of peripheral fasting plasma glucose tests |
| f102: The minimum value of peripheral fasting plasma glucose tests |
| f103: Number of times for random peripheral plasma glucose tests |
| f104: Number of times for random peripheral plasma glucose tests ≥ 11.1mmol/l (200mg/dl) |
| f105: The maximum value of random peripheral plasma glucose tests |
| f106: The minimum value of random peripheral plasma glucose tests |
| HbA1C test | f107: Number of times for HbA1c tests |
| f108: Number of times for HbA1C tests ≥ 6.5% |
| f109: The maximum value of HbA1C tests |
| f110: The minimum value of HbA1C tests |

**Appendix B: A list of diabetic medicine**

Medicine is a principal factor to characterize phenotypes of subjects with type 2 diabetes mellitus (T2DM). In this paper, we use prescribed medicine listed in Table A2 as one of our seven sources to construct medicine related features as listed in Table A1.

**Table A2.** A list of medicine associated with subjects with type 2 diabetes mellitus

|  |  |  |
| --- | --- | --- |
| **Category of medicine** | **Chinese generic name** | **Translated English generic name** |
| Western Medicine | 依帕司他 | Epalrestat (A medicine treating for diabetic neuropathy) |
| 阿卡波糖 | Acarbose (Alpha-glucosidase inhibitor) |
| 伏格列波糖 | Voglibose (Alpha-glucosidase inhibitor) |
| 米格列醇 | Miglitol (Alpha-glucosidase inhibitor) |
| 利拉利汀 | Linagliptin (Dipeptidylpeptidase IV(DPP-IV) inhibitors) |
| 沙格列汀 | Saxagliptin (Dipeptidylpeptidase IV(DPP-IV) inhibitors) |
| 维格列汀 | Vidagliptin (Dipeptidylpeptidase IV(DPP-IV) inhibitors) |
| 西格列汀 | Sitagliptin (Dipeptidylpeptidase IV(DPP-IV) inhibitors) |
| 那格列奈 | Nateglinide (Meglitinides) |
| 瑞格列奈 | Regalinide (Meglitinides) |
| 醋酸己脲 | Acetohexamide (Sulfonylureas) |
| 格列本脲 | Glyburide (Sulfonylureas) |
| 格列吡嗪 | Glipizide (Sulfonylureas) |
| 格列喹酮 | Gliquidone (Sulfonylureas) |
| 格列美脲 | Glimepiride (Sulfonylureas) |
| 格列齐特 | Gliclazide (Sulfonylureas) |
| 甲苯磺丁脲 | Tolbutamide (Sulfonylureas) |
| 氯磺丙脲 | Chlorpropamide (Sulfonylureas) |
| 马来酸罗格列酮和格列美脲 | Glimepiride and rosiglitazone |
| 西格列汀二甲双胍片 | Metformin and sitagliptin |
| 二甲双胍格列吡嗪 | Metformin and glipizide |
| 格列本脲盐酸二甲双胍 | Metformin and glyburide |
| 吡格列酮二甲双胍 | Metformin and pioglitazone |
| 二甲双胍马来酸罗格列酮片 | Metformin and rosiglitazone |
| 吡格列酮 | Pioglitazone (Thiazolidinediones) |
| 罗格列酮 | Rosiglitazone (Thiazolidinediones) |
| 曲格列酮 | Troglitazone (Thiazolidinediones) |
| 苯乙双胍 | Phenformin (Biguanides) |
| 二甲双胍 | Metformin (Biguanides) |
| 普兰林肽 | Pramlintide (Incretin Mimetics) |
| 艾塞那肽 | Exenatide symthetic (GLP-1(glucagon-like peptide 1) mimetics) |
| 利拉鲁肽 | Liraglutide (GLP-1(glucagon-like peptide 1) mimetics) |
| 利西拉来 | Lixisenatide (GLP-1 (glucagon-like peptide 1) mimetics) |
| Integration of Traditional Chinese Medicine and Western Medicine | 葛根消渴丸 | XiaoKeWan (The Root of Kudzu Vine) |
| 地黄消渴丸 | XiaoKeWan (Radices Rehmanniae) |
| 黄芪消渴丸 | XiaoKeWan (Astragalus Mongholicus) |
| 天花粉消渴丸 | XiaoKeWan (Radix Trichosanthis) |
| 玉米须消渴丸 | XiaoKeWan (Stigmata Maydis) |
| 南五味子消渴丸 | XiaoKeWan (Kadsura Longepedunculata) |
| 山药消渴丸 | XiaoKeWan (Chinese Yam) |
| 格列本脲消渴丸 | XiaoKeWan (Glibenclamide) |
| Traditional Chinese Medicine | 参花消渴茶 | ShenHuaXiaoKeCha (Ginseng, Astragalus Mongholicus, The Root of Kudzu Vine, Rhizoma Anemarrhenae, Radix Trichosanthis, Cortex Lycii Radicis, Radix Polygonati Officinalis, Green Tea, Rhizoma Phragmitis, Carthamus Tinctorious, The Dodder Weed, Gypsum, Platycodon Grandiflorum) |
| 参芪降糖 | ShenQiJiangTang (Panax Ginseng Leaves Extract,The Fruit of Chinese Magnoliavine, Astragalus Mongholicus, Chinese Yam, Radices Rehmanniae, Fructus Rubi, Radix Ophiopogonis, Poria Cocos, Radix Trichosanthis, The Rhizome of Oriental Water Plantain, The Fruit of Chinese Wolfberry) |
| 地骨降糖 | DiGuJiangTang (Radix Curcumae, Cortex Lycii Radicis, Fructus Perillae, Tortoise Shell, Lumbricus, Leech, Cordyceps Sinensis) |
| 甘露消渴 | GanLuXiaoKe (Prepared Rehmannia Root, Radices Rehmanniae, Cortex Lycii Radicis, Ginseng, The Fruit of Chinese Wolfberry, Astragalus Mongholicus, The Dodder Weed, Fructus Corni, Codonopsis Pilosula, Coptis Chinensis) |
| 降糖甲 | JiangTangJia (Astragalus Mongholicus, Rhizoma Polygonati, Radices Rehmanniae, Radix Pseudostellariae, Radix Trichosanthis, Ginseng, Chinese yam, Gypsum, Rhizoma Anemarrhenae, Astragalus Mongholicus, Radix Trichosanthis, Poria Cocos, Radix Ophiopogonis, Radix Rehmanniae Recens,  Cortex Lycii Radicis, Stigmata Maydis, Fructus Corni, Liquorice) |
| 降糖宁 | JiangTangNing (Ginseng, Chinese yam, Gypsum, Rhizoma Anemarrhenae, Astragalus Mongholicus, Radix Trichosanthis, Poria Cocos, Radix Ophiopogonis, Radix Rehmanniae Recens, Cortex Lycii Radicis, Stigmata Maydis, Fructus Corni, Liquorice) |
| 降糖舒胶囊 | JiangTangShuJiaoNang (Ginseng, The Fruit of Chinese Wolfberry, Astragalus Mongholicus, Radix et Caulis Acanthopanacis Senticosi, Rhizoma Polygonati, Semen Amomi Amari, Concha Ostreae, Radices Rehmanniae, Prepared Rehmannia Root, The Root of Kudzu Vine, The Root of Red-Rooted Salvia, Semen Litchi, Rhizoma Anemarrhenae, Gypsum, Semen Euryales, Chinese Yam, Radix Scrophulariae, The Fruit of Chinese Magnoliavine, Radix Ophiopogonis, The Root of Three-nerved Spicebush, Radix Trichosanthis, Fructus Aurantii) |
| 金芪降糖 | JinQiJiangTang (Pearl, Astragalus Mongholicus, Rhizoma Polygonati, Scutellaria Baicalensis, Radices Rehmanniae, Radix Trichosanthis, Radix Ophiopogonis, Dendrobe, Cicada Slough, Endothelium Corneum Gigeriae Galli, Chinese Yam, Semen Astragali Complanati, Pericarpium Citri Reticulatae Viride, The Root of Kudzu Vine ) |
| 晶珠糖尿康 | JingZhuTangNiaoKang (Fructus Chebulae, Carthamus Tinctorious, Amomum Kravanh, Rock Extract, Shellac, Radix Et Rhizoma Rubiae, Fructus Phyllanthi, Turmeric, Berberis Kansuensis Schneid, Tribulus Terrestris L., Lapis Micae Aureus, Juniperus Formosana, Saxifraga Umbellulata Hook. f. et Thoms, Corydalis Impatiens, Leguminosae, Bear Gall, Bos Taurus Domesticus Gmelin ) |
| 渴乐宁 | KeLeNing (Astragalus Mongholicus, Rhizoma Polygonati, Radices Rehmanniae, Radix Pseudostellariae, Radix Trichosanthis ) |
| 糖脉康 | TangMaiKang (Astragalus Mongholicus, Radix Rehmanniae Recens, The Root of Red-rooted Salvia, The Root of Kudzu Vine, Folium Mori, Herba Epimedii) |
| 糖尿乐 | TangNiaoLe (Radix Trichosanthis, Radix Ginseng Rubra, Chinese Yam, Astragalus Mongholicus, Radices Rehmanniae, The Fruit of Chinese Wolfberry, Rhizoma Anemarrhenae, Fructus Corni, The Root of Kudzu Vine,  The Fruit of Chinese Magnoliavine, Radix Asparagi, Poria Cocos, Endothelium Corneum Gigeriae Galli) |
| 糖脂消 | TangZhiXiao (Astragalus Mongholicus, The Root of Red-rooted Salvia, Stephania Tetrandra, Cortex Lycii Radicis, Coptis Chinensis, Bighead Atractylodes Rhizome) |
| 洗胰清糖素 | XiYiQingTangSu (Folium Mori, The Root of Kudzu Vine, Balsam Pear, Radix Polygonati Officinalis) |
| 消渴康 | XiaoKeKang (Gypsum, Rhizoma Anemarrhenae, Radix Rehmanniae Recens,  Radix Ophiopogonis, Radix Trichosanthis, Radix Polygonati Officinalis, Radix Scrophulariae, The Root of Bidentate Achyranthes, The Root of Red-rooted Salvia, The Rhizome of Oriental Water Plantain, Codonopsis Pilosula,  Fructus Corni, Folium Eriobotryae, Kadsura Longepedunculata) |
| 消渴灵片 | XiaoKeLing Pian (Radices Rehmanniae, The Fruit of Chinese Magnoliavine,  Radix Ophiopogonis, Cortex Moutan Radicis, Astragalus Mongholicus,  Coptis Chinensis, Poria Cocos, Radix Ginseng Rubra, Radix Trichosanthis,  Gypsum, The Fruit of Chinese Wolfberry) |
| 玉泉丸 | YuQuanWan (The Root of Kudzu Vine,Radix Trichosanthis, Radices Rehmanniae, Radix Ophiopogonis, The Fruit of Chinese Magnoliavine, Liquorice) |
| 珍芪降糖 | ZhenQiJiangTang (Pearl, Astragalus Mongholicus, Rhizoma Polygonati, Scutellaria Baicalensis, Radix Rehmanniae Recens, Radix Trichosanthis, Radix Ophiopogonis, Dendrobe, Cicada Slough, Endothelium Corneum Gigeriae Galli, Chinese Yam, Semen Astragali Complanati, Pericarpium Citri Reticulatae Viride, The Root of Kudzu Vine ) |

**Appendix C: A list of positive and negative diagnosis notes related with T2DM**

Diagnosis notes existing in diagnosis reports or clinical summaries are represented as unstructured texts. We create a dictionary of diagnosis notes related with T2DM. There are two types of diagnosis notes: positive and negative. We assume that if a subject’s EHR data contains positive diagnosis notes, but not negative diagnosis notes, then the positive diagnosis notes are counted to construct features associated with diagnosis notes.

**Table A3.** A list of positive and negative diagnosis notes related with T2DM

|  |  |  |
| --- | --- | --- |
| **Diagnosis note category** | **Chinese notes** | **Translated English notes** |
| **Positive diagnosis notes** | 2 型糖尿病 | Type 2 diabetes |
| 2-糖尿病 |
| 2型糖尿病 |
| 2-型糖尿病 |
| 2型糖尿病 |
| Ⅱ型糖尿病 |
| II 型糖尿病 |
| II糖尿病 |
| II型糖尿病 |
| 二型糖尿病 |
| 糖尿病 II型 |
| 糖尿病（Ⅱ型） |
| 糖尿病2 |
| 糖尿病2型 |
| 糖尿病Ⅱ型 |
| 糖尿病II |
| 糖尿病II型 |
| 非胰岛素依赖型糖尿病 | Noninsulin-dependent diabetes mellitus |
| 糖尿病 | Diabetes mellitus |
| **Negative diagnosis notes** | 排除糖尿病 | Exclusion of diabetes |
| 非糖尿病 |
| 糖尿病的特殊筛查 | Special screening for diabetes |
| 糖尿病特殊筛查 |
| 糖尿病母亲的婴儿综合征 | Syndrome of infant of diabetic mother |
| 糖尿病母亲的婴儿综合征 |
| 母亲伴妊娠糖尿病的婴儿综合征 |
| 妊娠糖尿病母亲婴儿综合征 |
| 糖尿病家族史 | Family history of diabetes mellitus |
| 潜伏性糖尿病 | Occult diabetes |
| 早期型糖尿病 | Early type diabetes |
| 隐性糖尿病 | Latent diabetes |
| 化学性糖尿病 | Chemical diabetes |
| 糖尿病前期 | Prediabetes |
| 胰岛素和口服降血糖[抗糖尿病]药中毒 | Oral hypoglycemic drug poisoning |
| 口服降血糖[抗糖尿病]药中毒 |

**Appendix D: A list of 36 features summarized from 110 features as listed in Table A1**

Features listed in Table A1 are extracted from seven sources, however, several features across sources are correlated. For instance, diagnosis-code related features appearing in “*communication report*”, “*outpatient diagnosis record*” and “*inpatient diagnosis record*” are similar. These features have the same definition in above three sources, so they can be summarized as a new feature. In this way, eight new features (f’10 to f’17) in the category of diagnosis codes as shown in Table A4 are summarized from 24 features (f10 to f17, f26 to f33, f50 to f57) from Table A1. By using the same way, we summarize 32 similar diagnosis-note related features appearing in “*communication report*” (f18 to f25), “*outpatient diagnosis record*” (f34 to f41), “*inpatient diagnosis record*” (f42 to f49) and “*inpatient discharge summary*” (f58 to f65) into 8 new features (f’18 to f’25) in the category of diagnosis notes as shown in Table A4.

Features as listed in the “*laboratory test report*” of Table A1 are also correlated with each other. For instance, features ranging from f83 to f86 are all correlated with venous 2-hours plasma glucose test. In order to reduce negative influences of correlated features on the performances of classification models such as k nearest neighbors, we only keep features which are positive signals of type 2 diabetes. For instance, feature f84 characterizing the number of times 2-hours plasma glucose test≥11.1mmol/l, which is a positive signal of type 2 diabetes conditions. So do feature f88, f92, f96, f100, f104 and f108.

Most of subjects only take a small number of medicine listed in Table A2, as a result, the data covering features ranging from f66 to f82 has a big sparsity, which will influence the performances of computational models to learn patterns of T2DM [1]. In order to avoid a big sparsity, we transform original features ranging from f66 to f69 into new ones ranging from f’26 to f’29 as shown in Table A4.

**Table A4.** The original 110 constructed features as shown in Table A1 are transformed into 36 features via summarizing similar features across seven sources: “*communication report*”, “*outpatient diagnosis record*”, “*inpatient diagnosis record*”, “*inpatient discharge summary*”, “*prescription report*” and “*laboratory report*”.

|  |  |
| --- | --- |
| **Category of features** | **New Merged Feature** |
| Demographic information | f’1 = f1 |
| f’2 = f2 |
| f’3 = f3 |
| Self-reporting notes | f’4 = f4 |
| f’5 = f5 |
| f’6 = f6 |
| f’7 = f7 |
| f’8 = f8 |
| f’9 = f9 |
| Diagnose codes | f’10=f10+f26+f50 |
| f’11=f11+f27+f51 |
| f’12=f12+f28+f52 |
| f’13=f13+f29+f53 |
| f’14=f14+f30+f54 |
| f’15=f15+f31+f55 |
| f’16=f16+f32+f56 |
| f’17=f17+f33+f57 |
| Diagnose notes | f’18=f18+f34+f42+f58 |
| f’19=f19+f35+f43+f59 |
| f’20=f20+f36+f44+f60 |
| f’21=f21+f37+f45+f61 |
| f’22=f22+f38+f46+f62 |
| f’23=f23+f39+f47+f63 |
| f’24=f24+f40+f48+f64 |
| f’25=f25+f41+f49+f65 |
| Medication | f’26 = f66 |
| f’27 = f67 |
| f’28 = f68 |
| f’29 = f69 |
| Plasma glucose and HbA1C tests | f’30=f84 |
| f’31=f88 |
| f’32=f92 |
| f’33=f96 |
| f’34=f100 |
| f’35=f104 |
| f’36=f108 |

**Appendix E: A list of 8 features summarized from 36 features as listed in Table A4**

36 features in Table A4 are summarized as 8 features in following 6 categories:

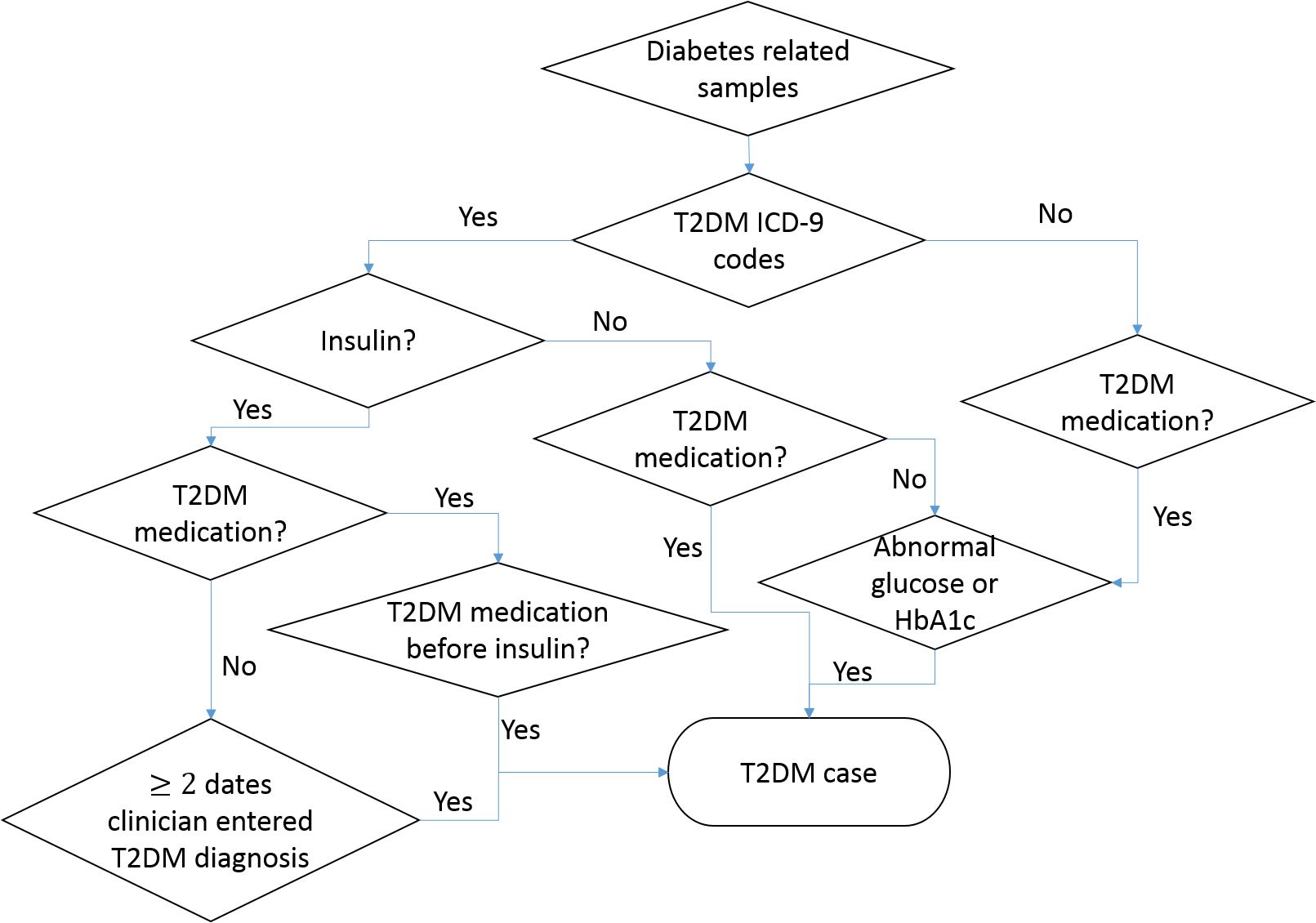
1. **Patients’ demographic information**: ranging from f’’1 to f’’3.
2. **Self-report**: summarize 6 features ranging from f’4 to f’9 in Table A4 as f’’4 in Table A5 to represent the total number of times diabetic phenomena such as body weight loss, persistent hunger, polyuria, polydipsia, prescribed diabetes medicine and returning visits for diabetes were reported by subjects in the source of “*communication report*”.
3. **Diagnosis code**: summarize 8 features ranging from f’10 to f’17 in Table A4 as f’’5 in Table A5 to represent the total number of times diabetic diagnosis-codes are assigned to a subject in “*communication report*”, “*outpatient diagnosis record*” and “*inpatient diagnosis report*”.
4. **Diagnosis note**: summarize 8 features ranging from f’18 to f’25 in Table A4 as f’’6 in Table A5 to represent the total number of times diabetic diagnosis-notes are described in a subject’s “*communication report*”, “*outpatient diagnosis record*”, “*inpatient diagnosis record*” and “*inpatient discharge summary*”.
5. **Medication**: summarize 4 features ranging from f’26 to f’29 in Table A4 as f’’7 in Table A5 to represent the total number of times diabetic medicines as listed in Table A2 are prescribed in a subject’s prescription record.
6. **Plasma glucose and HbA1C test**: summarize 7 features ranging from f’30 to f’36 in Table A4 as f’’8 in Table A5 to represent the total number of times venous plasma glucose, peripheral plasma glucose (fasting plasma glucose ≥126 mg/dl or 2-hours plasma glucose≥200 mg/dl or random plasma glucose ≥200 mg/dl) and HbA1C tests are abnormal.

**Table A5.** The 8 features after summarizing related features within a category such as “self-reporting note”, “diagnosis code”, “diagnosis note”, “medication”, “plasma glucose” and “HbA1C test”.

|  |  |
| --- | --- |
| **Category of features** | **Feature** |
| **Demographic information** | f’’1 = f’1 |
| f’’2 = f’2 |
| f’’3 = f’3; |
| **Self-reporting note** | f’’4 = f’4+ f’5+ f’6+ f’7+ f’8+ f’9 |
| **Diagnosis code** | f’’5 = f’10+ f’11+ f’12+ f’13+ f’14+ f’15+ f’16+ f’17 |
| **Diagnosis note** | f’’6 = f’18+ f’19+ f’20+ f’21+ f’22+ f’23+ f’24+ f’25 |
| **Medication** | f’’7 = f’26+ f’27+ f’28+ f’29 |
| **Plasma glucose and HbA1C test** | f’’8 = f’30+ f’31+ f’32+ f’33+ f’34+ f’35+ f’36 |

**Appendix F: Expert algorithm for the identification of subjects with T2DM**

The expert algorithm2 we used as our baseline to do performance comparisons is depicted in Figure A1. The performance of the algorithm had been successfully validated at multiple eMERGE Network3 sites in the USA. The algorithms utilized various types of information including diagnosis codes, medication orders, laboratory results and clinical notes. We applied this algorithm on all of our investigated EHR sources including diagnoses, laboratory results, medications, communication reports and clinical notes. Notably, the expert algorithm and our approach both used the same EHR sources.

**Figure A1.** Expert algorithm for the identification of subjects with T2DM

**Reference**

1. B. K. Natarajan**.** Sparse Approximate Solutions to Linear Systems. SIAM J. Comput. 1995; 24(2):227–234.
2. A. N. Kho, et.al. Use of diverse electronic medical record systems to identify genetic risk for type 2 diabetes within a genome-wide association study. Journal of the American Medical Informatics Association. 2012; 19(2):212-218
3. McCarty CA, et.al. The eMERGE Network: A consortium of biorepositories linked to electronic medical records data for conducting genomic studies. BMC Medical Genomics. 2011; 4:13