

Epidemiology Landscape and Impact of Overweight and Obesity in Adults: Multi-Country Results from the IMPACT-O Study

Esther Artime^{1*}, Erik Spaepen², Sarah Zimmer-Rapuch¹, Anastasia Lampropoulou¹, Atif Adam³, Xiaoyu Lin³, Mengyuan Shang³, Sarah Seager³, Carel W. Le Roux⁴, Dror Dicker^{5,6}

¹ Eli Lilly and Company, Indianapolis, Indiana, USA

² HaaPACS GmbH, Schriesheim, Germany

³ IQVIA Inc., London, UK

⁴ Diabetes Complications Research Centre, Conway Institute, University College Dublin, Dublin, Ireland

⁵ Department of Medicine and Obesity Clinic, Rabin Medical Center (HaSharon Hospital), Petah Tikva, Israel

⁶ Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

*** Correspondence:**

Esther Artime

artime_esther@lilly.com

Supplementary Material

Supplementary Tables

Supplementary Table S1. Key features of the OMOP data sources selected for the study.

Characteristics	France LPD	Germany DA	Italy LPD	Spain LPD	UK IMRD THIN	Australia EMR	Japan Claims
Type of data source	EMRs	EMRs	EMRs	EMRs	EMRs	EMRs	Claims
Cumulative people	17.5M	41.5M	2.4M	2.7M	14.0M	2.8M	15.2M
Active people ^a	3.6M	8.9M	1.0M	910.4K	1.7M	343.4K	6.6M
Data coverage ^b	27.0%	49.8%	4.0%	5.8%	20.7%	10.6%	12.3%
Dates of service ^{c,d}	2013 – 2022/12	1992 – 2022/12	2012 – 2022/09	2006 – 2022/12	1994 – 2022/09	2013 – 2022/12	2013 – 2022/05
Study period ^d	2018 – 2022/12	2018 – 2022/12	2018 – 2022/09	2018 – 2022/12	2018 – 2022/09	2018 – 2022/12	2018 – 2022/05
General practice providers	6.2K	1.2K	1.5K	3.6K	8.5M	8.7K	799.7K ^e
Specialist providers	3.0K	1.6K	No	51.5K	No	No	387.3K ^e
Ethics Committee review required	No	No	No	Yes	No	No	No
Prescription codes	France EMR custom	GRR	Italy EMR specific	Spain EMR specific	Gemscrip, Read	Australia EMR specific	Japan Claims specific
Diagnoses codes	ICD-10	ICD-10	ICD-9CM	ICD-9CM	Read	ICD-10	Japan Claims specific, ICD-10
Procedure codes	ICD-10	ICD-10	Italy EMR specific, ICD-9CM	Spain EMR specific, ICD-9CM	Read	ICD-10	Japan Claims specific

^a Active patients were those with at least one record or claim for diagnosis, prescription, procedure, device, measurement, or visit to care sites recorded in the database in the last 12 months.

^b Data coverage: proportion of cumulative patients divided by national population using as reference: <https://www.worldometers.info/world-population/population-by-country/>.

^c Dates of service: dates covered in the most recent database.

^d Dates indicate year/month.

^e Japan does not have general practitioners in their healthcare systems. Rather, patients' first point of contact is usually an internal medicine physician. These physicians do not deal with surgical cases.

Abbreviations: DA, disease analyzer; EMR, electronic medical record; GPs, general practitioners; GRR, Global Reference; ICD-9CM, International Classification of Diseases Clinical Modification, Ninth Revision; ICD-10, International Classification of Diseases, Tenth Revision; IMRD, IQVIA Medical Research Data; K, thousand; LPD, longitudinal patient database; M, million; OMOP, Observational Medical Outcomes Partnership; THIN, The Health Improvement Network.

Supplementary Table S2. Full list of BMI, overweight, and obesity codes used to identify individuals with overweight and obesity.

Variable	ID	Code	Name	Domain	Vocabulary
BMI	1002813	LP415677-6	BMI Patient General body weight	Measurement	LOINC
BMI	3038553	39156-5	BMI [Ratio]	Measurement	LOINC
BMI	4103471	301331008	Finding of BMI	Observation	SNOMED
BMI	4245997	60621009	BMI	Measurement	SNOMED
BMI	36304833	89270-3	BMI [Ratio] Estimated	Measurement	LOINC
BMI	36315265	10005894	BMI	Observation	MedDRA
BMI	36660808	LP417322-7	HEDIS 2020 Value Set - BMI Patient HEDIS panels	Measurement	LOINC
BMI	40756859	3008F	BMI, documented (PV)	Observation	CPT4
BMI	44783982	698094009	Measurement of BMI	Measurement	SNOMED
BMI	42622221	10087017	Maternal pre-pregnancy body mass index	Observation	MedDRA
BMI	42622838	10087012	Maternal BMI	Observation	MedDRA
Overweight	437525	238131007	Overweight	Observation	SNOMED
Overweight	4060705	162863004	BMI 25-29 – overweight	Observation	SNOMED
Overweight	4146858	268916007	O/E: weight greater than 20% over ideal	Condition	SNOMED
Overweight	4150937	268915006	O/E: weight 10–20% over ideal	Condition	SNOMED
Overweight	4175214	275947003	O/E: overweight	Observation	SNOMED
Overweight	36716554	722595002	Overweight in adulthood with BMI of 25 or more but less than 30	Observation	SNOMED
Obesity	380500	72894001	Hypertrophy of fat pad of knee	Condition	SNOMED
Obesity	433736	414916001	Obesity	Condition	SNOMED
Obesity	434005	238136002	Morbid obesity	Condition	SNOMED
Obesity	438731	270486005	Localized adiposity	Condition	SNOMED
Obesity	439893	44772007	Maternal obesity syndrome	Observation	SNOMED
Obesity	763588	443371000124107	Obese class I	Observation	SNOMED
Obesity	763589	443381000124105	Obese class II	Observation	SNOMED
Obesity	3199162	25630001000004106	Pregnancy complicated by obesity	Condition	Nebraska Lexicon
Obesity	4005991	111036000	Hyperinsular obesity	Condition	SNOMED
Obesity	4029276	238134004	Generalized obesity	Condition	SNOMED
Obesity	4029277	238135003	Fat pad syndrome	Condition	SNOMED
Obesity	4029900	238133005	Gynecoid obesity	Condition	SNOMED
Obesity	4037679	162690006	O/E: obese	Observation	SNOMED
Obesity	4060985	162864005	BMI 30+ – obesity	Observation	SNOMED
Obesity	4079899	238132000	Android obesity	Condition	SNOMED
Obesity	4087487	248311001	Central obesity	Condition	SNOMED
Obesity	4093860	248312008	Peripheral obesity	Condition	SNOMED
Obesity	4097929	292464007	Constitutional obesity	Condition	SNOMED
Obesity	4100857	190966007	Extreme obesity with alveolar hypoventilation	Condition	SNOMED
Obesity	4160821	290439001	Familial obesity	Condition	SNOMED

Obesity	4163032	293481008	Hyperplastic-hypertrophic obesity	Condition	SNOMED
Obesity	4171147	295509007	Hypertrophic obesity	Condition	SNOMED
Obesity	4171317	294493008	Lifelong obesity	Condition	SNOMED
Obesity	4171972	296526005	Adult-onset obesity	Condition	SNOMED
Obesity	4177337	5036006	Hypogonadal obesity	Condition	SNOMED
Obesity	4182506	297500005	Endogenous obesity	Condition	SNOMED
Obesity	4183240	298464002	Obesity of endocrine origin	Condition	SNOMED
Obesity	4185912	414438005	Hyperplastic obesity	Condition	SNOMED
Obesity	4189664	414918000	Obesity by age of onset	Observation	SNOMED
Obesity	4189665	414920002	Obesity by fat distribution pattern	Condition	SNOMED
Obesity	4203289	53146006	Hypothyroid obesity	Condition	SNOMED
Obesity	4211019	57337005	Steatopygia	Condition	SNOMED
Obesity	4212443	414917005	Obesity by adipocyte growth pattern	Condition	SNOMED
Obesity	4215968	414915002	Obese	Observation	SNOMED
Obesity	4215969	414919008	Obesity by contributing factors	Condition	SNOMED
Obesity	4216214	80660001	Mauriac's syndrome	Condition	SNOMED
Obesity	4217557	415530009	Simple obesity	Condition	SNOMED
Obesity	4220527	82793005	Hypothalamic obesity	Condition	SNOMED
Obesity	4235799	360566006	Buffalo obesity	Condition	SNOMED
Obesity	4256640	408512008	BMI 40+ – severely obese	Observation	SNOMED
Obesity	4270189	63702009	Alstrom syndrome	Condition	SNOMED
Obesity	4271317	62999006	Adiposogenital dystrophy	Condition	SNOMED
Obesity	35622038	763350002	Intellectual disability, obesity, brain malformation, facial dysmorphism syndrome	Condition	SNOMED
Obesity	36674490	774102003	Intellectual disability, obesity, prognathism, eye and skin anomalies syndrome	Condition	SNOMED
Obesity	36674827	770680004	Prader-Willi-like syndrome	Condition	SNOMED
Obesity	36674893	770750002	Intellectual disability, seizures, macrocephaly, obesity syndrome	Condition	SNOMED
Obesity	36678790	776204008	Colobomatous microphthalmia, obesity, hypogenitalism, intellectual disability syndrome	Condition	SNOMED
Obesity	36713437	717761005	Choroideremia with deafness and obesity syndrome	Condition	SNOMED
Obesity	36714072	719160009	Syndromic X-linked intellectual disability type 7	Condition	SNOMED
Obesity	36714548	719834005	Wilson Turner syndrome	Condition	SNOMED
Obesity	36716144	722037004	MEHMO syndrome	Condition	SNOMED
Obesity	36716151	722053001	Obesity due to prohormone convertase I deficiency	Condition	SNOMED

Obesity	36716555	722596001	Obesity caused by energy imbalance	Condition	SNOMED
Obesity	36717154	721231007	Hydrocephalus with obesity and hypogonadism syndrome	Condition	SNOMED
Obesity	36717199	722051004	Obesity, colitis, hypothyroidism, cardiac hypertrophy, developmental delay syndrome	Condition	SNOMED
Obesity	37018860	83911000119104	Severe obesity	Condition	SNOMED
Obesity	37110069	724137002	MOMO syndrome	Condition	SNOMED
Obesity	37204685	783549006	Obesity due to CEP19 deficiency	Condition	SNOMED
Obesity	37204691	783556000	Severe early-onset obesity insulin resistance syndrome due to SH2B1 deficiency	Condition	SNOMED
Obesity	37204815	783719006	Obesity due to SIM1 deficiency	Condition	SNOMED
Obesity	37206117	785722006	Obesity due to leptin receptor gene deficiency	Condition	SNOMED
Obesity	37208175	461341000124106	Lower body obesity	Condition	SNOMED
Obesity	37310479	1076711000119101	Hypertrophy of fat pad of left knee	Condition	SNOMED
Obesity	37310480	1076701000119104	Hypertrophy of fat pad of right knee	Condition	SNOMED
Obesity	37311728	819948005	Obese class III	Observation	SNOMED
Obesity	37311904	788996008	Obesity in adolescence	Condition	SNOMED
Obesity	37395980	715628009	MORM syndrome	Condition	SNOMED
Obesity	37397209	717269008	Obesity due to melanocortin 4 receptor deficiency	Condition	SNOMED
Obesity	42539192	15750121000119108	Severe obesity complicating pregnancy	Condition	SNOMED
Obesity	42872398	171000119107	Maternal obesity complicating pregnancy, childbirth and the puerperium, antepartum	Condition	SNOMED
Obesity	44811711	914721000000105	Obese class I (BMI 30.0 – 34.9)	Observation	SNOMED
Obesity	44811712	914731000000107	Obese class II (BMI 35.0 – 39.9)	Observation	SNOMED
Obesity	45757112	10750551000119100	Obesity in mother complicating childbirth	Condition	SNOMED
Obesity	45771307	702949005	Proopiomelanocortin deficiency syndrome	Condition	SNOMED

Abbreviations: BMI, body mass index; CPT4, Current Procedural Terminology; ID, identification; LOINC, Logical Observation Identifiers Names and Codes; MedRA, Medical Dictionary for Regulatory Activities; MEHMO, Mental retardation, Epileptic seizures, Hypogonadism, Microcephaly, and Obesity; MOMO, Macrosomia, Obesity, Macrocephaly, and Ocular abnormalities; MORM, Mental retardation, truncal Obesity, Retinal dystrophy, and Micropenis; O/E, observation/examination; PV, prostate volume; SNOMED, Systematized Nomenclature of Medicine.

Supplementary Table S3. Percentage of subjects in the prevalent cohort^a with ORCs.

Number of ORCs^b	France LPD (n=430,089)	Germany DA (n=437,130)	Italy LPD (n=170,119)	Spain LPD (n=163,824)	UK IMRD THIN (n=893,246)	Australia EMR (n=25,625)	Japan Claims (n=567,359)
0	40.4	36.1	15.1	15.3	28.8	31.9	36.9
1	23.7	23.3	19.2	17.1	23.4	19.8	21.5
2	15.2	15.4	18.2	17.8	23.1	18.6	14.4
3	10.6	10.6	16.9	17.5	15.9	14.5	10.4
4	5.7	6.4	13.1	14.4	6.5	7.8	6.8
≥1	59.6	63.9	85.0	84.7	71.2	68.2	63.1
≥2	35.9	40.6	65.8	68.1	47.9	48.3	41.6
≥5	4.4	8.3	17.6	18.4	2.4	7.4	10.0

All values represent the percentage of prevalent cohort.

^a Adults (≥18 years) with overweight or obesity (≥1 BMI record of ≥25.0 kg/m²) and an observation start date ≥12 months before the index date (date of highest BMI record) during 2018–2022.

^b Some complications were identified by diagnosis and/or medication.

Abbreviations: DA, disease analyzer; EMR, electronic medical record; IMRD, IQVIA Medical Research Data; LPD, longitudinal patient database; ORCs, obesity-related complications; THIN, The Health Improvement Network.

Supplementary Table S4. Frequency of all recorded ORCs of interest in the prevalent cohort.^a

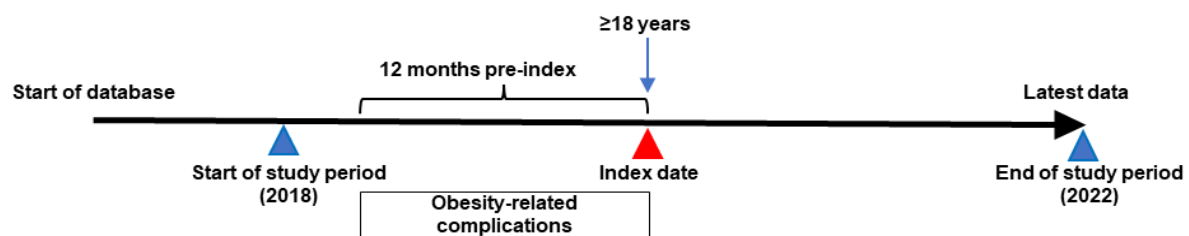
ORCs	France LPD (n=430,089)	Germany DA (n=437,130)	Italy LPD (n=170,119)	Spain LPD (n=163,824)	UK IMRD THIN (n=893,246)	Australia EMR (n=25,625)	Japan Claims (n=567,359)
Hypertension ^b	34.04%	42.22%	62.32%	57.80%	50.02%	44.78%	28.86%
Dyslipidemia ^b	20.39%	21.86%	40.19%	46.13%	34.47%	30.99%	20.96%
Heart failure	0.60%	3.97%	2.50%	3.00%	0.44%	1.19%	3.47%
HFpEF	0.00%	0.00%	0.00%	0.08%	0.01%	0.00%	0.00%
ASCVD	4.19%	7.76%	10.71%	7.17%	1.43%	3.77%	5.94%
Atrial fibrillation	0.58%	2.31%	5.48%	5.27%	0.96%	1.48%	0.19%
Cerebrovascular disease	1.54%	2.37%	6.84%	3.19%	0.53%	1.09%	1.75%
Stroke	0.45%	0.44%	1.07%	0.78%	0.34%	0.38%	0.13%
Coronary artery disease/ ischemic heart disease	2.88%	7.20%	7.11%	6.04%	0.96%	4.23%	3.37%
Atherosclerosis	1.36%	4.97%	2.06%	0.61%	0.20%	0.51%	2.07%
Peripheral arterial disease	0.29%	0.56%	0.53%	0.21%	0.03%	0.02%	0.42%
T2DM ^b	12.13%	18.54%	23.85%	25.86%	15.71%	16.59%	18.96%
Impaired glucose tolerance	0.00%	0.00%	0.00%	0.00%	0.89%	0.12%	0.00%
Asthma	5.21%	5.45%	8.53%	9.02%	2.17%	6.88%	23.11%
COPD	1.41%	4.04%	3.27%	0.51%	1.50%	2.41%	0.45%
OSA	— ^c	0.01%	— ^c	0.02%	0.18%	0.23%	0.02%
Osteoarthritis	9.75%	14.27%	27.10%	25.62%	4.47%	11.40%	17.02%
Low back pain	9.65%	5.33%	10.83%	13.68%	3.25%	1.90%	6.55%
Gout, including hyperuricemia	2.23%	4.62%	6.38%	5.39%	0.76%	3.32%	4.48%
Motor dysfunction	0.02%	0.11%	0.20%	0.20%	0.07%	0.03%	0.11%
MAFLD/MASH	0.60%	2.13%	1.41%	0.54%	0.54%	1.46%	5.82%
Chronic kidney disease	0.20%	2.05%	3.26%	3.27%	1.10%	0.84%	0.61%
Depression ^b	8.79%	8.41%	15.75%	21.49%	27.52%	18.93%	4.14%
Anxiety ^b	12.32%	4.45%	12.34%	28.68%	7.89%	11.26%	5.92%
Dementia	0.13%	0.75%	0.62%	1.20%	0.28%	0.27%	0.07%
Migraine	1.77%	1.12%	1.20%	2.82%	0.70%	1.88%	0.85%
Disorder of reproductive system	1.31%	1.07%	1.08%	2.03%	0.55%	1.17%	1.75%
Breast cancer	0.39%	0.64%	1.94%	0.59%	0.14%	0.35%	0.59%
Esophagus cancer	0.01%	0.02%	0.01%	0.01%	0.02%	0.01%	0.31%
Prostate, endometrial, ovarian, liver cancer	0.28%	0.55%	1.31%	0.95%	0.19%	0.44%	3.44%
Kidney cancer	0.03%	0.11%	0.35%	0.05%	0.01%	0.03%	0.22%
Gastroesophageal disease	5.25%	4.49%	14.97%	4.34%	0.74%	11.47%	5.73%
Urinary incontinence	0.09%	0.13%	0.20%	0.24%	0.11%	0.09%	0.03%

^a Adults (≥18 years) with overweight/obesity (≥1 BMI record of ≥25.0 kg/m²) and an observation start date ≥12 months before the index date (date of highest BMI record) during 2018–2022.

^b Complications identified by diagnosis codes and/or medication.

^c Less than ten patients.

Abbreviations: ASCVD, atherosclerotic cardiovascular disease; BMI, body mass index; COPD, chronic obstructive pulmonary disease; DA, disease analyzer; EMR, electronic medical record; HFpEF, heart failure with preserved ejection fraction; IMRD, IQVIA Medical Research Data; LPD, longitudinal patient database; MAFLD, metabolic-associated fatty liver disease; MASH, metabolic-associated steatohepatitis; ORCs, obesity-related complications; OSA, obstructive sleep apnea; T2DM, type 2 diabetes mellitus; THIN, The Health Improvement Network.

Supplementary Figure

Supplementary Figure S1. Study time-period for the prevalent cohort. The index date was the individual's highest record of BMI measurement ≥ 25.0 kg/m² in the study period. Abbreviation: BMI, body mass index.