

Validity of ICD-10 diagnoses of overweight and obesity in Danish hospitals

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Purpose: Health care databases may be a valuable source for epidemiological research in obesity, if diagnoses are valid. We examined the validity and completeness of International Classification of Diseases, 10th revision [ICD-10] diagnosis coding for overweight/obesity in Danish hospitals.

Patients and methods: We linked data from the Danish National Patient Registry on patients with a hospital diagnosis code of overweight/obesity (ICD-10 code E66) with computerized height and weight measurements made during hospital contacts in the Central Denmark Region Clinical Information System. We computed the positive predictive value (PPV) of the ICD-10 diagnosis of overweight/obesity, using a documented body mass index (BMI) ≥ 25 kg/m² as gold standard. We also examined the completeness of obesity/overweight diagnosis coding among all patients recorded with BMI ≥ 25 kg/m².

Results: Of all 19,672 patients registered with a first diagnosis code of overweight/obesity in the National Patient Registry, 17,351 patients (88.2%) had any BMI measurement recorded in the Central Denmark Region Clinical Information System, and 17,240 patients (87.6%) had a BMI ≥ 25 kg/m², yielding a PPV of 87.6% (95% CI: 87.2–88.1). The PPV was slightly higher for primary diagnosis codes of overweight/obesity: 94.1% (95% CI: 93.3–94.8) than for secondary diagnosis codes: 86.1% (95% CI: 85.6–86.6). The PPV increased with higher patient age: from 75.3% (95% CI: 73.8–76.9) in those aged 18–29 years to 94.7% (95% CI: 92.6–96.9) in patients aged 80 years and above. Completeness of obesity/overweight diagnosis coding among patients recorded with BMI ≥ 25 kg/m² was only 10.9% (95% CI: 10.8–11.0).

Conclusion: Our findings indicate a high validity of the ICD-10 code E66 for overweight/obesity when recorded; however, completeness of coding was low. Nonetheless, ICD-10 discharge codes may be a suitable source of data on overweight/obesity for epidemiological research.

Keywords: obesity, validation, diagnosis code

Introduction

Obesity is a globally increasing health problem and a risk factor for major diseases including diabetes,¹ cardiovascular disease,² cancer,^{3,4} and premature death.^{5–9} Obesity may also influence the clinical course of many medical diseases.^{10–20} Therefore, valid data on obesity are important in many epidemiological studies of risk and prognosis.

Hospital diagnosis codes for overweight and obesity exist in the ICD,⁴ and the prevalence of hospital contacts with diagnoses of overweight/obesity has increased in Denmark during the past decades.^{21,22} Use of hospital discharge registries can be a valuable and cost-effective source for epidemiological research in obesity, if diagnoses are valid. More than 20 years ago, Wolk et al validated the use of the

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ICD, version 8, diagnosis code for obesity (ICD-8 code 277) in the Swedish National Patient Register.³ They found a positive predictive value (PPV) of obesity diagnosis of 85% among women and 95% among men, when compared with the patients' medical charts as gold standard.³ In the newer ICD-10 coding classification system, the diagnosis code for obesity (ICD-10 code E66) contains several subtypes, ranging from overweight (E660A) to morbid obesity (E660G and E660H). In the United Kingdom, Nicholson et al reported a high validity of overweight and overweight diagnosis codes, registered by general practitioners.²³ On the other hand, not all patients with overweight/obesity may have information on BMI documented in their Electronic Health Record.²⁴ To our knowledge, despite its potential importance, the ICD-10 hospital diagnosis of obesity has never been validated in a population-based health care system.²⁵

We therefore examined the PPV of ICD-10 overweight and obesity diagnoses in the population-based Danish National Patient Registry (DNRP), using computerized BMI measurements from individual-level hospital contacts in the Central Denmark Region Clinical Information System (CDRCIS) as the reference. Second, we examined the completeness of overweight/obesity diagnosis coding among patients with a BMI measurement ≥ 25 kg/m².

Materials and methods

Setting and data sources

The Danish National Board of Health and the five Danish administrative Regions provide unrestricted tax-supported health care to all 5.81 million Danish residents, including hospital care.²⁶ The Central Denmark Region has a mixed rural and urban population of approximately 1.32 million persons. This Region has five hospitals, of which one is a university hospital and four are regional hospitals. The Danish Civil Registration System assigns a unique, central personal registration number (CPR number) to each resident, either at birth or upon immigration, which allows unambiguous individual-level linkage of health registries.²⁶

The DNRP provides information on all non-psychiatric contacts at any hospital in Denmark.²⁵ All inpatient hospital admissions have been tracked since 1977 and all visits at hospital outpatient clinics and emergency rooms have been recorded since 1995. All contacts are coded by treating physicians according to the ICD-10 system since 1994 and before that according to the ICD-8 (1977–1993). The DNRP compiles data on hospital, department,

admission and discharge dates, one primary (first-listed) and up to 19 secondary diagnosis codes, and type of admission (elective inpatient/acute inpatient/outpatient).²⁵ In recent years, for all hospitals in the Central Denmark Region, information on patients' height, weight, and selected lifestyle risk factors have been registered in the computerized CDRCIS. At each individual patient contact with any hospital – either during an inpatient hospitalization course or at a hospital outpatient clinic visit – nurses or physicians can obtain data on height, weight and/or BMI through patient interview and examination, and then electronically record these data in the CDRCIS together with the contact date and the patient's unique CPR number.²²

Overweight and obesity diagnosis codes

For our validation study, we first identified all unique persons with one or more inpatient or outpatient hospital contacts at any hospital in the Central Denmark Region, 2012–2015 (n=755,656), using the DNRP (Figure 1, flow chart). Among these persons, we then identified those who had at least one primary or secondary ICD-10 discharge diagnosis code E66 (overweight or obesity) between 2012 and 2015. If persons had more than one diagnosis date with E66 coded during 2012–2015, we included the most recent registered E66 diagnosis date only. Furthermore, we examined subgroups within the E66 diagnosis code category, based on the most recent registered code 2012–2015: E660A: overweight, BMI 25–29.9 kg/m², E660B: obesity, BMI 30–34.9 kg/m², E660C: severe obesity, BMI 35–39.9 kg/m², E660E: morbid obesity, BMI 40–44.9 kg/m², E660F: morbid obesity, BMI 45–49.9 kg/m², E660G: super obesity, BMI 50–54.9 kg/m², E660H: super obesity, BMI ≥ 55 kg/m² (Table 1).

Validation of diagnoses by BMI

We used the CPR-number to link individual-level diagnosis data from the DNRP (overweight/obesity diagnosis codes and dates) with time-stamped height/weight/BMI data from the CDRCIS. For each patient with an overweight/obesity diagnosis code during 2012–2015, we assessed the presence of any records of height, weight and/or BMI in the CDRCIS during 2011–2016, to allow for 1 year of early or delayed electronic BMI recordings, respectively.

We calculated BMI from any registered height (during the whole study period, assuming stable height) and weight measurements registered in the CDRCIS. If a

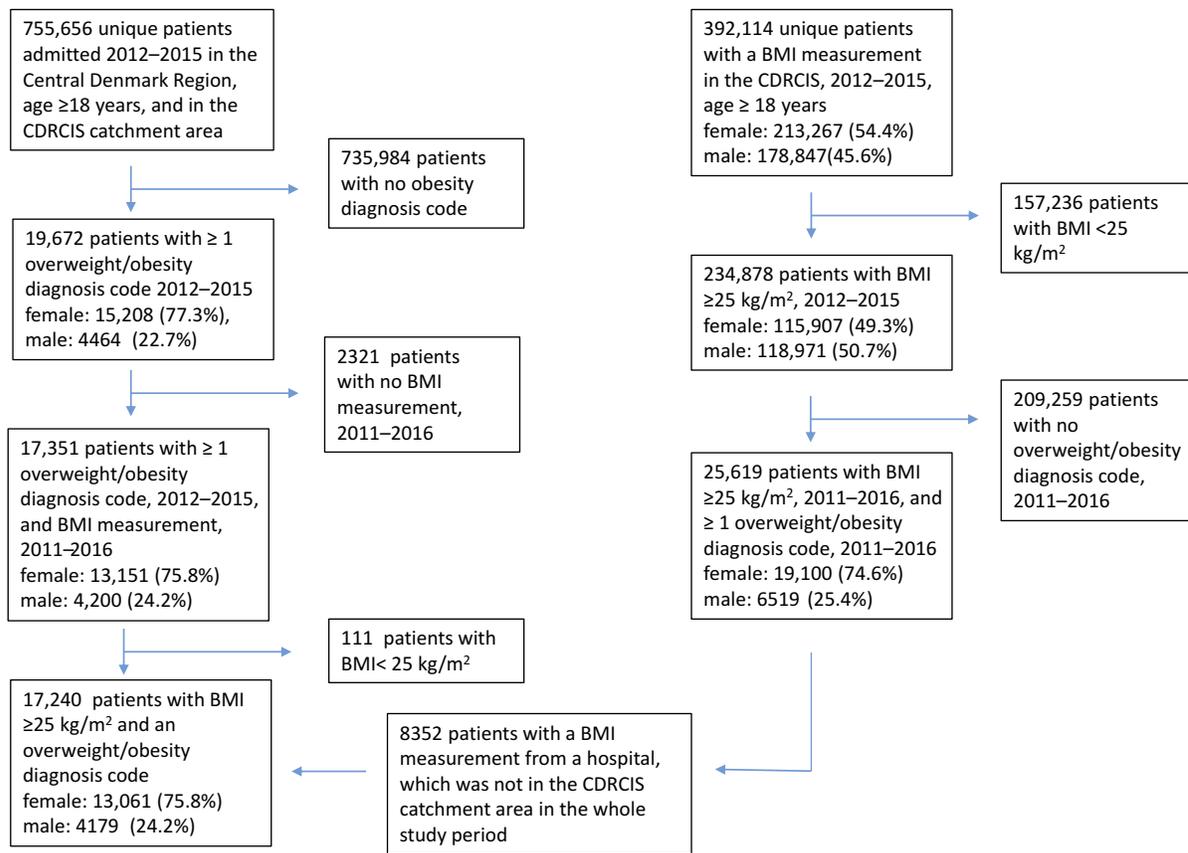


Figure 1 Flow chart: inclusion and exclusion of patients.

Abbreviations: CDRCIS, Central Denmark Region Clinical Information System; BMI, body mass index.

Table 1 List of overweight and obesity diagnosis codes, according to the International Classification of Diseases, 10th edition

Diagnosis code	Diagnosis name
DE66	Overweight and obesity
DE660	Obesity due to excess calories
DE660A	Overweight, BMI 25–29.9
DE660B	Obesity, BMI 30–34.9
DE660C	Severe obesity, BMI 35–39.9
DE660D	
DE660E	Morbid obesity, BMI 40–44.9
DE660F	Morbid obesity, BMI 45–49.9
DE660G	Super obesity, BMI 50–54.9
DE660H	Super obesity, BMI ≥55
DE66I	Drug-induced obesity
DE662	Extreme obesity with alveolar hypoventilation
DE662A	Pickwickian syndrome
E668	Other overweight or obesity
E669	Overweight, not classified elsewhere

Abbreviation: BMI, body mass index.

calculated BMI value was present for a patient in the CDRCIS, we used that value. We used a BMI ≥ 25 kg/m² as gold standard and classified patients with a BMI ≥ 25

kg/m² as having overweight or obesity in our main analysis, since both overweight and obesity are included in the E66 diagnosis code category and since some of the E66 subcategories include both conditions (E668: other overweight or obesity and E669: overweight not classified elsewhere).

Completeness of overweight/obesity coding among patients with a BMI measurement ≥ 25 kg/m²

Second, we focused on all patients with a BMI measurement in the CDRCIS, identifying all patients with a BMI measurement ≥ 25 kg/m² 2012–2015 as our starting point (N=234,878, Figure 1, flow chart). From the DNPR we thereafter identified any overweight/obesity diagnosis code given at any Danish hospital, including nationwide DNPR data in the period 2011–2016.

Due to structural changes in the Region’s health care system some hospitals were in the CDRCIS electronic data catchment area during the first years of study, 2011–2013, but not in the whole study period. BMI results from these

hospitals were included in the analyses of false negative results, but not in the main analyses.²⁷

Statistical analyses

The PPV was defined as the proportion of patients registered with an obesity diagnosis in the DNPR that was confirmed by a record of measured BMI ≥ 25 kg/m², 2011–2016 (gold standard). We also performed a sensitivity analysis including only BMI measurements 1 year before/after the overweight/obesity diagnosis code. The numerator was a confirmed BMI ≥ 25 kg/m² in the CDRCIS, and the denominator was the number of patients with an overweight/obesity code in the DNPR. The 95% CIs were calculated using Jeffrey's method.²⁸ Persons with an overweight/obesity diagnosis code may lack a confirmatory BMI ≥ 25 kg/m² value, either when BMI was not measured and/or electronically documented ("missing BMI"), or when a BMI value was documented but was < 25 kg/m² ("BMI value not overweight/obese"). Our analysis was a "worst case analysis", counting both persons with missing BMI and persons with BMI value not overweight/obese in the "overweight/obesity not confirmed" category (some overweight/obese patients likely had a BMI ≥ 25 kg/m² measured in clinical care, which was just not entered into the electronic system for various reasons).

We stratified the PPV analysis by sex, age, admission type (acute inpatient admission/elective inpatient admission/hospital outpatient clinic visit), primary versus secondary diagnosis code, department type (medical, surgical, emergency, gynecological and obstetric, or any other department), and by hospital. In a secondary analysis, we assessed the completeness of E66 coding among patients with a BMI ≥ 25 kg/m² in the CDRCIS. Here, the numerator was the number of patients with an overweight/obesity code in the DNPR, and the denominator was a confirmed BMI ≥ 25 kg/m² in the CDRCIS. Finally, we used multivariate logistic regression to examine predictors of diagnosis coding of overweight/obesity, using age group 18–29 years, female gender, hospital contact in the first year 2012, and residency in the Central Denmark Region as reference groups, expressed as odds ratios and adjusted odds ratios (aOR).

The study was approved by the Danish Data Protection Agency (Record Number KEA-2016-051-000001, 401). According to Danish legislation, purely registry-based studies do not require separate approval from the Danish

Scientific Ethics Committee. All analyses were conducted using SAS statistical software (version 9.3).

Results

In total, we identified 19,672 patients who had one or more hospital contacts with an E66 overweight/obesity diagnosis code between 2012 and 2015. Among these, 17,351 patients (88.2%) had at least one measurement of BMI recorded 2011–2016 (main analysis). A total of 17,240 (87.6%) had a BMI ≥ 25 kg/m², corresponding to an overall PPV for overweight/obesity of 87.6% (95% CI: 87.2–88.1) (Table 2).

Most patients (15,856, 80.6%) had their BMI measured within 1 year before/after the overweight/obesity diagnosis: and 15,689 (79.8%) had a BMI ≥ 25 kg/m², yielding a PPV of 79.8 (95% CI: 79.2–80.3) when focusing on BMI values within 1 year (Table 3). The following results are reported for BMI measurements available during the whole study period (Table 2); corresponding data for ± 1 year BMI values only are shown in Table 3.

The PPV was higher among men: 93.6% (95% CI: 92.9–94.3) than women: 85.9% (95% CI: 85.3–86.4), and the PPV increased with increasing patient age: it was 75.3% (95% CI: 73.8–76.9) in those aged 18–29 years versus 94.7 (95% CI: 92.6–96.9) in patients aged 80 years and above (Table 2). The PPV was higher for primary diagnosis codes: 94.1% (95% CI: 93.3–94.8) than secondary diagnosis codes: 86.1% (95% CI: 85.6–86.6).

Diagnosis subtype

The PPV for the presence of any overweight/obesity generally increased with increasing obesity category, up to a PPV of 97.6% (95% CI: 96.3–99.0) for patients coded with an E660F: morbid obesity diagnosis code. We found the highest proportion of missing BMIs among patient with a code for E660H: super obesity: 18.1% (Table 2).

Admission type

For acutely admitted patients, the PPV was 89.6 (95% CI: 88.2–91.0). For patients with an elective admission, the PPV was 94.0 (95% CI: 93.0–94.9), and for patients with a hospital outpatient clinic contact, the PPV was 86.4 (95% CI: 85.8–86.9).

Completeness of coding

In total, 234,878 patients had a BMI ≥ 25 kg/m² registered in the CDRCIS, but only 25,619 had an overweight/obesity

Table 2 Validity of ICD-10 codes for presence of overweight/obesity among 19,672 patients in the Central Denmark Region, 2012–2015, based on BMI measurements

	Total	Confirmed overweight/obesity	Not confirmed overweight/obesity	No BMI recorded	Positive predictive value, (95% CI)
		BMI ≥ 25 kg/m ²	BMI < 25 kg/m ²		
	N	n (%)	n (%)	n (%)	%
Total	19,672	17,240 (87.6)	111 (0.6)	2321 (11.8)	87.6 (87.2–88.1)
Age					
18–29	3058	2304 (75.3)	21 (0.7)	733 (24.0)	75.3 (73.8–76.9)
30–39	4338	3475 (80.1)	37 (0.9)	826 (19.0)	80.1 (78.9–81.3)
40–49	3772	3448 (91.4)	22 (0.6)	302 (8.0)	91.4 (90.5–92.3)
50–59	3317	3100 (93.5)	18 (0.5)	199 (6.0)	93.5 (92.6–94.3)
60–69	3086	2917 (94.5)	6 (0.2)	163 (5.3)	94.5 (93.7–95.3)
70–79	1682	1599 (95.1)	6 (0.4)	77 (4.6)	95.1 (94.0–96.1)
80+	419	397 (94.7)	1 (0.2)	21 (5.0)	94.7 (92.6–96.9)
Gender					
Female	15,208	13,061 (85.9)	90 (0.6)	2057 (13.5)	85.9 (85.3–86.4)
Male	4464	4179 (93.6)	21 (0.5)	264 (5.9)	93.6 (92.9–94.3)
Year					
2012	2697	2208 (81.9)	19 (0.7)	470 (17.4)	81.9 (80.4–83.3)
2013	3928	3404 (86.7)	24 (0.6)	500 (12.7)	86.7 (85.6–87.7)
2014	4962	4395 (88.6)	39 (0.8)	528 (10.6)	88.6 (87.7–89.5)
2015	8085	7233 (89.5)	29 (0.4)	823 (10.2)	89.5 (88.8–90.1)
Diagnosis type					
Primary	3786	3561 (94.1)	19 (0.5)	206 (5.4)	94.1 (93.3–94.8)
Secondary	15,886	13,679 (86.1)	92 (0.6)	2115 (13.3)	86.1 (85.6–86.6)
Diagnosis subtypes					
E660A: Overweight, BMI 25–29.9	3161	2733 (86.5)	54 (1.7)	374 (11.8)	86.5 (85.3–87.7)
E660B: Obesity, BMI 30–34.9	4107	3630 (88.4)	3 (0.1)	474 (11.5)	88.4 (87.4–89.4)
E660C: Severe obesity, BMI 35–39.9	2387	2195 (92.0)	1 (0.0)	191 (8.0)	92.0 (90.9–93.0)
E660E: Morbid obesity, BMI 40–44.9	1359	1283 (94.4)	1 (0.1)	75 (5.5)	94.4 (93.2–95.6)
E660F: Morbid obesity, BMI 45–49.9	465	454 (97.6)	0 (0.0)	11 (2.4)	97.6 (96.3–99.0)
E660G: Super obesity, BMI 50–54.9	184	176 (95.7)	0 (0.0)	8 (4.3)	95.7 (92.7–98.6)
E660H: Super obesity, BMI ≥ 55	116	95 (81.9)	0 (0.0)	21 (18.1)	81.9 (74.9–88.9)
E660, E661, Other obesity	1652	1477 (89.4)	13 (0.8)	162 (9.8)	89.4 (87.9–90.9)
E662. Extreme obesity with alveolar hypoventilation	137	124 (90.5)	0 (0.0)	13 (9.5)	90.5 (85.6–95.4)
E668, E669: Obesity, unspecified	6104	5073 (83.1)	39 (0.6)	992 (16.3)	83.1 (82.2–84.0)
Department					
Medical	4995	4587 (91.8)	34 (0.7)	374 (7.5)	91.8 (91.1–92.6)
Surgical	1802	1659 (92.1)	35 (1.9)	108 (6.0)	92.1 (90.8–93.3)
Emergency	375	362 (96.5)	0 (0.0)	13 (3.5)	96.5 (94.7–98.4)
Gynecological and obstetric	3464	3313 (95.6)	5 (0.1)	146 (4.2)	95.6 (95.0–96.3)
Other	9036	7319 (81.0)	37 (0.4)	1680 (18.6)	81.0 (80.2–81.8)
Admission type					
Acute inpatient	1837	1646 (89.6)	1 (0.1)	190 (10.3)	89.6 (88.2–91.0)
Elective inpatient	2458	2310 (94.0)	35 (1.4)	113 (4.6)	94.0 (93.0–94.9)
Outpatient	15,377	13,284 (86.4)	75 (0.5)	2018 (13.1)	86.4 (85.8–86.9)

Abbreviation: BMI, body mass index.

Table 3 Validity of ICD-10 codes for the presence of overweight/obesity among 19,672 patients in the Central Denmark Region, 2012–2015, based on BMI measurements 1 year before/after the diagnosis date

	Total	Confirmed overweight/obesity	Not confirmed overweight/obesity	No BMI recorded	Positive predictive value, (95% CI)
		BMI ≥ 25 kg/m ²	BMI < 25 kg/m ²		
	N	n (%)	n (%)	n (%)	%
Total	19,672	15,689 (79.8)	167 (0.8)	3816 (19.4)	79.8 (79.2–80.3)
Age					
18–29	3058	1980 (64.7)	25 (0.8)	1053 (34.4)	64.7 (63.1–66.4)
30–39	4338	3083 (71.1)	47 (1.1)	1208 (27.8)	71.1 (69.7–72.4)
40–49	3772	3198 (84.8)	47 (1.2)	527 (14.0)	84.8 (83.6–85.9)
50–59	3317	2875 (86.7)	25 (0.8)	417 (12.6)	86.7 (85.5–87.8)
60–69	3086	2703 (87.6)	11 (0.4)	372 (12.1)	87.6 (86.4–88.8)
70–79	1682	1489 (88.5)	8 (0.5)	185 (11.0)	88.5 (87.0–90.0)
80+	419	361 (86.2)	4 (1.0)	54 (12.9)	86.2 (82.9–89.5)
Gender					
Female	15,208	11,786 (77.5)	141 (0.9)	3281 (21.6)	77.5 (76.8–78.2)
Male	4464	3903 (87.4)	26 (0.6)	535 (12.0)	87.4 (86.5–88.4)
Year					
2012	2697	1899 (70.4)	18 (0.7)	780 (28.9)	70.4 (68.7–72.1)
2013	3928	3039 (77.4)	48 (1.2)	841 (21.4)	77.4 (76.1–78.7)
2014	4962	4069 (82.0)	60 (1.2)	833 (16.8)	82.0 (80.9–83.1)
2015	8085	6682 (82.6)	41 (0.5)	1362 (16.8)	82.6 (81.8–83.5)
Diagnosis type					
Primary	3,786	3405 (89.9)	32 (0.8)	349 (9.2)	89.9 (89.0–90.9)
Secondary	15,886	12,284 (77.3)	135 (0.8)	3467 (21.8)	77.3 (76.7–78.0)
Diagnosis subtypes					
E660A: Overweight, BMI 25–29.9	3161	2518 (79.7)	84 (2.7)	559 (17.7)	79.7 (78.3–81.1)
E660B: Obesity, BMI 30–34.9	4107	3336 (81.2)	7 (0.2)	764 (18.6)	81.2 (80.0–82.4)
E660C: Severe obesity, BMI 35–39.9	2387	2033 (85.2)	5 (0.2)	349 (14.6)	85.2 (83.7–86.6)
E660E: Morbid obesity, BMI 40–44.9	1359	1221 (89.8)	1 (0.1)	137 (10.1)	89.8 (88.2–91.5)
E660F: Morbid obesity, BMI 45–49.9	465	434 (93.3)	1 (0.2)	30 (6.5)	93.3 (91.1–95.6)
E660G: Super obesity, BMI 50–54.9	184	169 (91.8)	0 (0.0)	15 (8.2)	91.8 (87.9–95.8)
E660H: Super obesity, BMI ≥ 55	116	87 (75.0)	0 (0.0)	29 (25.0)	75.0 (67.1–82.9)
E660, E661, Other obesity	1652	1319 (79.8)	25 (1.5)	308 (18.6)	79.8 (77.9–81.8)
E662. Extreme obesity with alveolar hypoventilation	137	115 (83.9)	0 (0.0)	22 (16.1)	83.9 (77.8–90.1)
E668, E669: Obesity, unspecified	6104	4457 (73.0)	44 (0.7)	1603 (26.3)	73.0 (71.9–74.1)
Department					
Medical	4995	4176 (83.6)	65 (1.3)	754 (15.1)	83.6 (82.6–84.6)
Surgical	1802	1511 (83.9)	62 (3.4)	229 (12.7)	83.9 (82.2–85.6)
Emergency	375	344 (91.7)	0 (0.0)	31 (8.3)	91.7 (88.9–94.5)
Gynecological and obstetric	3464	3192 (92.1)	9 (0.3)	263 (7.6)	92.1 (91.3–93.0)
Other	9036	6466 (71.6)	31 (0.3)	2539 (28.1)	71.6 (70.6–72.5)
Admission type					
Acute inpatient	1837	1530 (83.3)	5 (0.3)	302 (16.4)	83.3 (81.6–85.0)
Elective inpatient	2458	2203 (89.6)	65 (2.6)	190 (7.7)	89.6 (88.4–90.8)
Outpatient	15,377	11,956 (77.8)	97 (0.6)	3324 (21.6)	77.8 (77.1–78.4)

Abbreviation: BMI, body mass index.

diagnosis codes registered during 2011–2016. Thus, completeness of diagnostic coding was only 10.9% (95% CI: 10.8–11.0), implying that 89.1% of patients with a hospital documented BMI ≥ 25 kg/m² were not given an overweight/obesity diagnosis code. These patients may be described as false negative overweight/obese when assessed through ICD-10 diagnoses only (Table 4). Diagnosis completeness improved with calendar time, and was clearly lower among men (5.5%) than women (16.5%), corresponding to an aOR in men of 0.30 (95% CI; 0.29–0.31). Completeness was highest among adults aged 30–39 years at 17.8% (aOR=1.21 (95% CI; 1.16–1.27) versus adults aged 20–29 years), and then decreased with increasing age, ie, diagnosis completeness at 80+ years 3.3% (aOR=0.20 (95% CI; 0.18–0.22)).

Discussion

To our knowledge, this is the first general hospital-based study validating hospital diagnosis codes for overweight and obesity in the ICD-10 system. We took advantage of a computerized clinical information system and found a high overall PPV indicating high validity of ICD-10 codes for overweight or obesity when compared to medical records of clinical weight/height or BMI measurements. This applied both to primary and secondary diagnosis codes of overweight/obesity. False positive diagnoses usually related to total absence of any available BMI records in the information system; when BMI values were available, they were almost always of correct value, ie, ≥ 25 kg/m². On the other hand, completeness of ICD-10 diagnosis coding was low among patients with hospital documented BMI ≥ 25 kg/m².

Table 4 Completeness of obesity/overweight diagnosis coding in the Danish National Patient Registry, 2012–2015, among patients with a BMI ≥ 25 kg/m² registered in the Central Denmark Region Clinical Information System

	DE66 overweight/ obesity diagnosis code n (%)	No DE66 overweight/ obesity diagnosis code n (%)	Completeness (95% CI)	Crude OR (95% CI)	Adjusted OR* (95% CI)	Total
All	25,619 (10.9)	209,259 (89.1)	10.9 (10.8–11.0)	–		234,878
Age						
18–29	3397 (15.1)	19,088 (84.9)	15.1 (14.6–15.6)	Reference	Reference	22,485
30–39	5109 (17.8)	23,674 (82.2)	17.8 (17.3–18.2)	1.21 (1.16–1.27)	1.21 (1.16–1.27)	28,783
40–49	5030 (13.9)	31,050 (86.1)	13.9 (13.6–14.3)	0.91 (0.87–0.95)	0.99 (0.94–1.04)	36,080
50–59	4521 (11.0)	36,719 (89.0)	11.0 (10.7–11.3)	0.69 (0.66–0.73)	0.77 (0.73–0.80)	41,240
60–69	4333 (8.9)	44,163 (91.1)	8.9 (8.7–9.2)	0.55 (0.53–0.58)	0.63 (0.60–0.66)	48,496
70–79	2559 (6.8)	35,142 (93.2)	6.8 (6.5–7.0)	0.41 (0.39–0.43)	0.45 (0.43–0.48)	37,701
80+	670 (3.3)	19,423 (96.7)	3.3 (3.1–3.6)	0.19 (0.18–0.21)	0.20 (0.18–0.22)	20,093
Gender						
Female	19,100 (16.5)	96,807 (83.5)	16.5 (16.3–16.7)	Reference	Reference	115,907
Male	6519 (5.5)	112,452 (94.5)	5.5 (5.4–5.6)	0.29 (0.29–0.30)	0.30 (0.29–0.31)	118,971
Year						
2012	2162 (7.6)	26,194 (92.4)	7.6 (7.3–7.9)	Reference	Reference	28,356
2013	3966 (9.0)	39,982 (91.0)	9.0 (8.8–9.3)	1.20 (1.14–1.27)	1.19 (1.13–1.26)	43,948
2014	6395 (10.1)	56,789 (89.9)	10.1 (9.9–10.4)	1.36 (1.30–1.44)	1.38 (1.31–1.45)	63,184
2015	13,096 (13.2)	86,294 (86.8)	13.2 (13.0–13.4)	1.84 (1.75–1.93)	1.98 (1.89–2.08)	99,390
Residence						
In the Central Denmark Region	21,905 (10.4)	188,822 (89.6)	10.4 (10.3–10.5)	Reference	Reference	210,727
Not in the Central Denmark Region	3714 (15.4)	20,437 (84.6)	15.4 (14.9–15.8)	1.57 (1.51–1.63)	1.59 (1.53–1.66)	24,151

Notes: *"Age" adjusted for gender, year, and residence, "Gender" adjusted for age, year, and residence, "Year" adjusted for age, gender, and residence, and "Residence" adjusted for age, gender, and year.

Our findings suggest that the use of overweight/obesity diagnosis codes in hospital diagnosis registries has a great potential in future epidemiological studies, when several considerations are taken into account. Due to the uniform structure of the Danish health care system, our results can be assumed generalizable within Denmark, as we examined hospitals including the whole Central Denmark Region.

Our findings of a high validity of overweight/obesity diagnosis codes corroborate previous results of Wolk et al and Nicholson et al.^{3,23} Barriers may be present among health care professionals, leading to avoidance of measuring BMI in some patients and underreporting of obesity.²⁹ Although large weight changes may sometimes occur within months, eg, associated with severe illness, bariatric surgery, or strict diet, most people take years to obtain substantial changes in their body weight.³⁰ In accordance, we found a high validity of overweight/obesity diagnoses, even when the assessment period for BMI values was extended to several years before and after the diagnosis.

Our results of a clearly higher PPV among men than women correspond to the findings of Wolk et al.³ Possibly, high body weight is a taboo to a higher degree among women than men.³¹ We speculate that health care professionals might have a lower propensity of weighing their female versus male patients and document their BMI, either due to their own or patient barriers; however, we have not been able to identify any studies on this topic. On the other hand, both Nicholson et al²³ and we found that both the overall frequency of BMI measurements, and the related completeness of overweight/obesity diagnosis coding in those with increased BMI, was much higher among women than men. This may be related to the Danish pregnancy care program, by which it is mandatory to measure women's BMI during their pregnancy and report their habitual weight before pregnancy.³² Finally, in the DNPR, three of four contacts are registered for women, thus the gender difference in the amount of overweight/obesity diagnosis codes in our study may reflect the overall contact pattern regarding gender differences.

Among patients with super obesity ICD-10 diagnostic categories corresponding to BMI ≥ 55 kg/m², we found decreasing PPVs due to missing BMI measurements in the CDRCIS. We suspect this may be due to everyday practical problems, as some hospital scales have a maximum weight which unable patients within the super-obese category to use them. In contrast, among patients with a BMI between 45.0 and 49.9 kg/m², completeness was high, which to some extent may be explained by the fact that patients within this

BMI range may be candidates for bariatric surgery, augmenting focus on exact BMI measurements.³³

The PPV was also slightly higher for patients who were admitted acutely than those who were seen in hospital outpatient clinics. In the outpatient clinic, patients may have been followed for several years. If patients had their BMI measured early in their outpatient course, ie, before our data catchment period started in 2011, we did not have their BMI records available in the CDRCIS, whereas diagnosis codes of overweight/obesity may have been transferred to new contacts in the outpatient course after 2011.

In contrast to their rather high validity, we found large underreporting of overweight/obesity diagnoses, with only one of ten patients with BMI ≥ 25 kg/m² actually receiving this diagnosis code. Obesity per se is rarely a primary cause of hospital admission, although it may be an important contributing factor to many acute admissions, eg, with cardiovascular events, gastrointestinal diseases, infections, etc.²² This likely explains much of the underreporting, as doctors are usually focused on principle (first-listed) diagnoses, ie, on the primary cause of admission when registering codes. Secondary listed diagnosis codes usually do not play a major role in government reimbursement of hospitals. Furthermore, BMI measurement is often performed by a nurse on the admission day, while diagnosis coding in Denmark is done by a doctor at the time of discharge, disconnecting in time the two registrations. In US primary care, Baer et al reported an overall completeness of any BMI registration of 66% in the Electronic Health Record,²⁴ clearly higher than in our hospital-based setting. Patients are likely to consult their general practitioner with different issues than hospital specialist physicians, including more lifestyle issues. Baer et al also examined the completeness of overweight and obesity diagnostic coding among those with BMI ≥ 25 kg/m² and found values of 17–30% in primary care, higher than our estimate of 10%. As in our study, female gender and younger age predicted higher completeness. Future epidemiological studies drawing on patients with ICD-10 overweight/obesity codes should take into account that included patients may be more likely to be young and female, as compared with the typical hospitalized patients with obesity.

A number of limitations have to be considered when interpreting our study results. Over 4 years, approximately one-third of Central Denmark's population (1.32 million) experienced any hospital contact, and one of six got a BMI measurement recorded in the hospital system. Overall, our

results suggest that 3% (19,672/755,656) of all patients with hospital contact in the Central Denmark Region received an overweight/obesity diagnosis, while 60% (234,878/392,114) of those with any measured BMI at hospitals had a BMI-value ≥ 25 kg/m².

Though more than half of all persons with hospital contact (52%, 392,114/755,656) had their BMI registered in the CDRCIS, the true prevalence of overweight or obesity in Danish hospitals is unknown, as we do not have BMI values available on all hospitalized patients. A recent Danish general population survey found that 47.4% had BMI ≥ 25 kg/m², including 14.1% with BMI ≥ 30 kg/m².³⁴ Thus, the proportion of patients with BMI ≥ 25 kg/m² in the CDRCIS is similar to that of the general population, which makes it plausible to extrapolate the data to other Danish hospitals. In comparison, Sogaard et al reported that only 0.8% of all hospitalized patients in Denmark received an overweight/obesity diagnosis in the period 1999–2012.²¹ Thus, we experience an increasing use of overweight/obesity diagnosis codes over time.

We drew on electronic data from the CDRCIS, and did not retrieve any possible handwritten/manually available BMI measurements/charts that may not have been correctly computerized and reported in the CDRCIS, possibly underestimating the true PPV of the diagnoses. Furthermore, some patients may have had their BMI measured outside the hospital prior to admission, eg, at their general practitioner, and a hospital diagnosis of overweight/obesity may have been given based on such primary care BMI data, which we could not identify. Finally, we do not know to which extent our study findings are representative for other hospital systems outside Denmark, where both prevalence of overweight and obesity and diagnostic and coding strategies may be different.

Conclusion

This large hospital-based study provides evidence for a high validity of the ICD-10 code E66 for overweight or obesity, when compared with actual clinical weight and height measurements in computerized medical records in Denmark. Although the completeness of overweight/obesity coding among people with documented BMI ≥ 25 kg/m² in hospitals is low, discharge codes for overweight/obesity may be a suitable data source for epidemiological research.

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Data availability

Data are available as presented in the paper. According to Danish legislation, our own approvals to use the Danish data sources for the current study do not allow us to distribute or make patient data directly available to other parties. Interested researchers may apply for data access through the Research Service at the Danish Health Data Authority (e-mail: kd.atadsdehdnus@ecivresreksrof; phone: +45 3268 5116). Up-to-date information on data access is available online (<http://sundhedsdatastyrelsen.dk/da/forskerservice>). Access to data from the Danish Health Data Authority requires approval from the Danish Data Protection Agency (<https://www.datatilsynet.dk/english/the-danish-data-protection-agency/introduction-to-the-danish-data-protection-agency/>). The authors do not have special access privileges to these data.

Disclosure

The authors report no conflicts of interest in this work.

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