Metabolic syndrome is associated with similar long-term prognosis in non-obese and obese patients. An analysis of 45 615 patients from the nationwide LIPIDOGRAM 2004-2015 cohort studies.

Kamila Osadnik[1]*, Tadeusz Osadnik[1]*, Marek Gierlotka[2], Adam Windak[3], Tomasz Tomasik[4], Mirosław Mastej[5], Agnieszka Kuras[6], Kacper Jóźwiak[7], Peter E. Penson[8-10], Gregory Y.H. Lip[11,12], Dimitri P. Mikhailidis[13], Peter P. Toth[14,15], Alberico L. Catapano[16,17], Kausik K. Ray[18], George Howard[19], Maciej Tomaszewski[20,21], Fadi J. Charchar[22], Naveed Sattar[23], [24]Bryan Williams, Thomas M. MacDonald[25], Maciej Banach[14,26-28#], Jacek Jóźwiak[29#] on behalf of the LIPIDOGRAM Investigators**

**KO, TO - equally first contributed authors; #MB, JJ - equally senior contributed authors*

[1]Department of Pharmacology, Medical University of Silesia, Katowice, Poland; [2]Department of Cardiology, University of Opole, Opole, Poland; [3]Department of Family Medicine, Jagiellonian University Medical College, Krakow, Poland; [4]Department of Family Medicine, Jagiellonian University Medical College, Krakow, Poland; [5]Mastej Medical Center, Jasło, Poland; [6]Multiprofile Medical Simulation Center, University of Opole, Opole, Poland; [7]Faculty of Health Sciences, Jagiellonian University Medical College, Krakow, Poland; [8]Clinical Pharmacy & Therapeutics Research Group, School of Pharmacy and Biomolecular Sciences, Liverpool John Moores University, Liverpool, UK; [9]Liverpool Centre for Cardiovascular Science, University of Liverpool, Liverpool, UK; [10]Department of Cardiovascular and Metabolic Medicine, Institute of Life Course and Medical Sciences, University of Liverpool, Liverpool, UK; [11]Liverpool Centre for Cardiovascular Science (LCCS) at University of Liverpool, Liverpool Heart and Chest Hospital, Liverpool John Moores University, Liverpool, UK; [12]Department of Clinical Medicine, Aalborg University, Aalborg, Denmark; [13]Department of Clinical Biochemistry, Royal Free Hospital Campus, University College London Medical School, University College London (UCL), London, UK; [14]Cicarrone Center for the Prevention of Cardiovascular Disease, Johns Hopkins University School of Medicine, Baltimore, MD, USA; [15]CGH Medical Center, Sterling, IL, USA; [16]Department of Pharmacological and Biomolecular Sciences, University of Milan, Milan, Italy; [17]IRCCS MultiMedica, Sesto S. Giovanni, Milan, Italy; [18]Imperial Centre for Cardiovascular Disease Prevention, Department of Primary Care and Public Health, Imperial College London, London, UK; [19]University of Alabama at Birmingham, Birmingham, AL, USA; [20]Division of Cardiovascular Sciences, Faculty of Medicine, Biology and Health, University of Manchester, Manchester, UK; [21]Manchester Academic Health Science Centre, Manchester University NHS Foundation Trust, Manchester, UK; [22]School of Health and Life Sciences, Federation University Australia, Ballarat, VIC, Australia; [23]Institute of Cardiovascular and Medical Science, University of Glasgow, Glasgow, UK; [24]NIHR University College London

Biomedical Research Centre, University College London and University College London Hospitals NHS Foundation Trust, London, UK; [25]MEMO Research, Ninewells Hospital and Medical School, University of Dundee, Dundee, UK; [26]Department of Preventive Cardiology and Lipidology, Medical University of Lodz (MUL), Lodz, Poland; [27]Department of Cardiology and Adult Congenital Heart Diseases, Polish Mother's Memorial Hospital Research Institute (PMMHRI), Lodz, Poland [28]Cardiovascular Research Centre, University of Zielona Gora, Zielona Gora, Poland; [29]Department of Family Medicine and Public Health, Faculty of Medicine, University of Opole, Opole, Poland.

Running Title: *Lean metabolic syndrome and long-term prognosis*

Corresponding authors:

Prof. Maciej Banach, MD, PhD, FNLA, FAHA, FESC, FASA, Head, Department of Preventive Cardiology and Lipidology, Medical University of Lodz (MUL), Rzgowska 281/289; 93-338 Lodz, Poland. **Phone:** +48 42 639 37 71; **Fax:** +48 42 639 37 71; **E-mail:** maciej.banach@umed.lodz.pl

Prof. Jacek J. Jozwiak, MD, PhD; Head, Department of Family Medicine and Public Health, Faculty of Medicine, University of Opole, Oleska 48, 45-052 Opole, Poland; **Phone:** +48 77 4527557; **Fax:** +48 77 4527557, **E-mail:** jacek.jozwiak.1234@gmail.com

ABSTRACT:

Aims: We aimed to evaluate the association between metabolic syndrome (MetS) and long-term all-cause mortality.

Methods: The LIPIDOGRAM studies were carried out in the primary care in Poland in 2004, 2006 and 2015. MetS was diagnosed based on the National Cholesterol Education Program, Adult Treatment Panel III (NCEP/ATP III) and Joint Interim Statement (JIS) criteria. The cohort was divided into four groups: non-obese patients without MetS, obese patients without MetS, non-obese patients with MetS and obese patients with MetS. Differences in all-cause mortality was analyzed using Kaplan-Meier and Cox regression analyses.

Results: 45,615 participants were enrolled (mean age 56.3, standard deviation: 11.8 years; 61.7% female). MetS was diagnosed in 14,202 (31%) by NCEP/ATP III criteria, and 17,216 (37.7%) by JIS criteria. Follow-up was available for 44,620 (97.8%, median duration 15.3 years) patients. MetS was associated with increased mortality risk among the obese (hazard ratio, HR: 1.88 [95% CI, 1.79-1.99] and HR: 1.93 [95% CI 1.82-2.04], according to NCEP/ATP III and JIS criteria, respectively) and non-obese individuals (HR: 2.11 [95% CI 1.85-2.40] and 1.7 [95% CI, 1.56-1.85] according to NCEP/ATP III and JIS criteria respectively). Obese patients without MetS had a higher mortality risk than non-obese patients without MetS (HR: 1.16 [95% CI 1.10-1.23] and HR: 1.22 [95%CI 1.15-1.30], respectively in subgroups with NCEP/ATP III and JIS criteria applied).

Conclusions. MetS is associated with increased all-cause mortality risk in non-obese and obese patients. In patients without MetS obesity remains significantly associated with mortality. The concept of metabolically healthy obesity should be revised.

Keywords: Metabolic syndrome, Lean metabolic syndrome, obesity

Lay summary.

Metabolic syndrome (MetS) is used to describe a constellation of metabolic disturbances such as elevated blood glucose, increased levels of triglycerides (TG) and decreased level of high-density lipoprotein cholesterol (HDL-C). They are often accompanied by elevated blood pressure and central obesity, defined as increased waist circumference. Usually, those metabolic disturbances occur in obese individuals, but sometimes they can also occur in lean subjects. This relatively recent concept is often referred to as lean MetS.

A key conclusion from our paper is that MetS, when it occurs in lean patients, is associated with similarly unfavorable long-term prognosis as in obese patients. Additionally, our analysis shows that, lean patients with MetS are less often treated with lipid lowering drugs despite having higher low-density lipoprotein cholesterol levels (LDL-C).

An additional finding, that is important from a public health perspective, is that obese patients who do not fulfill MetS criteria have higher long-term all-cause mortality than their lean counterparts without MetS. This finding should be an argument to encourage maintenance of normal body weight.

INTRODUCTION

Obesity is a growing epidemic worldwide.[1] Overweight and obesity affects almost 60% of adults in the European Union (EU).[2] Obesity does not simply represent a state of excess weight, it is also associated with higher rates of insulin resistance, type 2 diabetes mellitus (T2DM), hypertension (HTN), dyslipidemia, coronary heart disease (CHD), obstructive sleep apnea, non-alcoholic fatty liver diseases and some malignancies, including endometrial, breast, and colon cancer. It is also the leading risk factor for disability.[3,4] Abnormal body mass index (BMI) and waist circumference (WC) have consistently been associated with adverse health outcomes over long term follow-up[5–7] including those secondary to the development of the metabolic syndrome (MetS). [3,4]

Definitions of MetS have been proposed by World Health Organization (WHO), European Group for the Study of Insulin Resistance (EGIR)[8], National Cholesterol Education Program Adult Treatment Panel III (NCEP/ATP III)[9,10], American Association of Clinical Endocrinology (AACE)[8], International Diabetes Federation (IDF)[11] and the American Heart Association/National Heart, Lung and Blood Institute (AHA/NHLBI)[12] . The first definition was created by WHO in 1998 with insulin resistance as an obligatory criterion of MetS as for the EGIR definition.[13] In 2005, IDF proposed a definition with central obesity or BMI ≥30 kg/m^2 as an obligatory criterion for the diagnosis of MetS.[14] In the remaining definitions (NCEP/ATP III, AACE and AHA/NHLBI), and Joint Interim Statement Consensus (JIS) 2009 definition[15] central obesity, along with impaired glucose tolerance, elevated blood pressure, and dyslipidemia, were no longer obligatory criteria for diagnosing MetS.[8,9,12,15]

Obesity is not synonymous with MetS, because some obese patients do not have metabolic disorders that meet the criteria of the syndrome. On the other hand, some lean patients

suffer from disorders of carbohydrate and lipid metabolism; have elevated blood pressure, and fulfill the criteria for the diagnosis of MetS. Recent studies suggest that metabolic disorders are also highly prevalent in lean individuals. In an Italian cohort, Buscemi et al.[16] using a definition of MetS not based on anthropometric parameters, observed that 27.4% of the overweight-obese participants were metabolically healthy while 36.7% of the normal-weight participants were metabolically unhealthy. As a result, the concepts of metabolically healthy obesity and lean MetS have emerged.[17–19] Moreover, recent research has also revealed that an abnormal metabolic profile, rather than elevated BMI, is linked with higher risk of T2DM, coronary heart disease[20–22] and stroke. [23–26]

The present analysis aimed to assess the association between metabolic health and obesity with mortality in an adult cohort representative of Polish patients in a primary care setting over a 15-year follow-up period.

METHODS

Study design

A nationwide cohort study was conducted in 2004, 2006 and 2015 in primary health care practices in Poland with follow-up to assess all-cause mortality. Information about the deaths of the recruited patients, based on a unique identification number for each participant, was extracted from the database of the Central Statistical Office. Death registration is mandatory in Poland. The study protocol complied with the Declaration of Helsinki and was approved by the Bioethical Committee of the Polish Chamber of Physicians (no. 51/2004/U) for years 2004/ 2006 and by the Bioethical Commission of the District Medical Chamber in Częstochowa (no K.B.Cz.–0018/2015) for years 2015.

Study Population

LIPIDOGRAM is a nationwide survey of cardiovascular risk factors carried out through primary care outpatient centers in Poland in 2004, 2006 and 2015. The methodology of each of the LIPIDOGRAM surveys has been described in detail. [27,28] Briefly, physicians were selected randomly, using Medical Data Management Software. The number of physicians in each of the administrative regions in Poland was selected in a manner proportional to the number of inhabitants. Patients aged ≥18 years were eligible for recruitment. Exclusion criteria included an inability to provide informed consent and incomplete clinical or biochemical data (e.g., due to blood sample loss). In 2004, a total of 675 primary care physicians actively enrolled 17,522 individuals in 444 towns/cities. In 2006, 556 primary care practitioners from 402 Polish cities recruited a total of 15,465 patients, while in 2015 a group of 438 physicians also in primary care practices recruited an additional 13,724 patients. We excluded patients that were recruited more than once in the subsequent LIPIDOGRAM surveys, including 1627 from the LIPIDOGRAM PLUS substudy and 113 patients that were recruited in 2004 or 2006 and 2015. Additionally, we excluded 43 patients that were mistakenly recruited twice during the same LIPIDOGRAM edition. Follow-up data was collected up to December 2021. A study flow chart is presented in **Figure 1.**

Anthropometric measurements and physical examination.

Height and weight measurements were carried out by nurses or physicians on patients in their underwear and barefoot. The BMI was calculated by dividing body weight in kilograms (kg) by squared height in meters (m) [kg/m^2]. WC was measured at the midpoint between the lower margin of the ribs and the anterior superior iliac crest spine in centimeters (cm). In 2015 physicians also measured heart rate and office BP.[28] They used standard

sphygmomanometers and implemented a procedure compliant with the European guidelines for the management of arterial hypertension. [29]

Biochemical analyses

Blood samples were collected after fasting (>12h following last meal). After centrifugation, blood samples were transferred to a core facility for processing. Biochemical analyses were performed within 12h after blood sample collection. Serum concentrations of total cholesterol were measured using a photometric method. High density lipoprotein (HDL) cholesterol (HDL-C) and triglycerides were measured by immunoseparation-based homogenous assay and colorimetric enzymatic test with glycerol-3-phosphateoxidase, respectively (DiaSys – Diagnostic Systems, Holzheim, Germany). Low density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula (2004 and 2006 LIPIDOGRAM surveys) or was measured directly (2015 LIPIDOGRAM surveys). Fasting blood glucose levels, for patients recruited in LIPIDOGRAM 2015 edition, was measured using a glucometer (Bionime, Taichung City, Taiwan) and Rightest strip tests (Bionime Taichung City, Taiwan).

Definitions

MetS was diagnosed according to the NCEP/ATP III definition[10] and for the purpose of comparison according to JIS 2009 definition[15]. To fulfill definition of MetS according to the NCEP/ATP III and JIS definition of MetS ≥3 out of 5 criteria had to be met (**Table 1**). Patients within BMI categories of <25, 25-29.9 or ≥30 kg/m^2 were considered as lean, overweight, and obese, respectively. Central obesity was defined as waist circumference (WC) ≥ 102 cm in men and ≥ 88cm in women. Based on the presence of MetS and obesity (defined as BMI ≥ 30 kg/m^2 or central obesity), the study cohort was divided into four groups: 1) non-obese patients without MetS, 2) non-obese patients with MetS, 3) obese patients, without MetS and, 4) obese subjects with MetS.

Patients were also grouped into five age categories. Young adults were defined as participants between 18-35 years old, early middle-aged adults were defined as 36-49 years, old late middle-aged adults were defined as 50-64 years old.[30] Patients between 65-74 years were defined as early elderly, and those aged 75 years or older were described as late elderly.[31]

Statistical analyses

Continuous variables are presented by means and standard deviations (SD). The comparison of continuous variables was performed using Student's t-tests. The comparison of dichotomous variables was performed using the chi-square test. Associations between obesity (BMI ≥ 30 kg/m^2 or central obesity) and presence of MetS defined according to NCEP/ATP III[9] and JIS[15] criteria and long-term outcome in the whole cohort and predefined age groups were analyzed using Kaplan-Meier estimates. Kaplan-Meier analysis was also carried out in patients with MetS to explore associations between BMI categories and mortality in patients with MetS. To assess the magnitude of influence of different clinical variables on long-term outcome, after checking the proportional hazards assumption, a univariate Cox regression model was used. Associations between clinical variables and age groups were tested using the Jonckheere-Terpstra test for trend in continuous data and the Cochrane-Armitage test for trend in categorical data. As data on glucose level and blood pressure were only available for patients recruited in the 2015 LIPIDOGRAM survey (Figure 1), to verify results from the whole cohort a separate survival analysis was performed only in patients recruited in 2015. A Two-sided p <0.05 was considered statistically significant.

RESULTS

Clinical characteristics

Whole cohort

45,615 participants were enrolled in the study (mean age 56.3 (SD -11.8) years and 61.7% were female). MetS was diagnosed in 14,202 (31%) by NCEP/ATP III criteria and 17,216 (37.7%) by JIS 2009 JIS criteria (**Table 2**). Patients with MetS were older, more likely to be female and less likely to have secondary or higher education (Table 2, Table S1, Table S2). Individuals in late middle age were about twice as likely as young adults to meet the criteria for MetS. Elderly patients were about three times as likely as young adults and early middle-aged individuals to meet the criteria for MetS (**Table S4**). The prevalence of obesity (BMI ≥ 30 kg/m^2 or central obesity), hypertension and dyslipidemia were higher in the MetS group regardless of definition Table 2. Patients with MetS were less likely to report physical activity, were more likely to receive lipid-lowering therapy, and had a higher blood pressure and glucose levels. HDL-C levels were lower and triglycerides levels were higher in patients with MetS. No significant differences (JIS definition), or very small differences (NCEP/ATP III definition) in LDL-C were observed. TC levels were slightly higher among patients without MetS (**Table 2, Table S1, S2).**

Clinical characteristics of patients with MetS according to BMI categories.

Out of the entire cohort 11,307 (24.8%) patients had BMI below 25 kg/m2, 19,134 (41.9%) were overweight and 15,174 (33.3%) had BMI ≥ 30 kg/m^2. Application of NCEP/ATP III definition as compared to JIS definition led to less frequent diagnosis of MetS especially in lean (7.1% vs. 12.5%) and overweight (25.9% vs. 35.6%) patients. Table 4.

In the group of lean patients with MetS, there were more females, while diabetes and hypertension were less prevalent in this subgroup of patients with MetS. Triglycerides were higher in lean patients with MetS diagnosed according to NCEP/ATP III criteria. Lean patients with MetS were also less likely to be treated with statins and fibrates despite significantly higher triglyceride and LDL-C levels compared participants with overweight and obese MetS.

Smoking was most prevalent in lean subjects compared with obese and overweight individuals (**Table 4**).

Long term prognosis

Whole cohort

Follow-up data were available for 44,620 (97.8%) of patients. Median follow-up was 15.3 years [interquartile range IQR 5.7-17.2]. There were 7559 (16.9%) deaths during follow-up. Mortality risks for each of the metabolic health categories are given in **Table 3**. The most important predictors of all-cause mortality were history of myocardial infarction (HR: 3.08, 95%CI 2.89-3.28, p<0.0001) and diabetes (HR: 2.71, 95% CI 2.66-2.86, p <0.0001). Table S3. Irrespective of diagnostic criteria, MetS was associated with worse long-term outcomes in obese (BMI ≥ 30 or central obesity) and non-obese individuals as compared to obese and non-obese patients without MetS (Figure 2 A, B, Table 3 and Table S4). MetS was associated with higher risk of death in obese and non-obese patients after the first five years of follow-up according to NCEP/ATP III criteria (HR: 1.7, 95% CI, 1.53 – 1.89, p <0.0001 and HR: 1.93, 95% CI 1.55 – 2.4, respectively), and JIS definition (HR: 1.74, 95% CI, 1.56 – 1.93, p <0.0001 and HR: 1.57, 95% CI, 1.34 – 1.84, p <0.0001, respectively). Throughout the whole observation period, obese and non-obese patients with MetS had a similarly increased risk of death when MetS diagnosed based on both the NCEP/ATP III definition (HR: 1.88, 95% CI 1.78-1.98, p<0.0001 and HR: 2.11, 95% CI 1.85-2.39, p<0.0001 respectively) and JIS criteria (HR: 1.93 , 95% CI 1.82 – 2.04 , p <0.0001 and HR: 1.7, 95%CI 1.56 – 1.85, p <0.0001).

In the first five years of observation obese (BMI ≥ 30 kg/m^2 or central obesity) patients without MetS had similar prognosis as their non-obese counterparts regardless of MetS definition applied (HR: 0.96, 95% CI, 0.85 – 1.09, p=0.51, NCEP/ATP III criteria and HR: 1.0, 95% CI 0.88 – 1.14, p=0.98, JIS criteria). In contrast to the initial five years of observation,

obese patients without MetS diagnosed according to NCEP/ATP III or JIS criteria had a higher risk of dying throughout the whole observation period, than non-obese patients without MetS (HR: 1.16, 95% CI, 1.10 – 1.23, p<0.0001 and HR: 1.22, 95% CI 1.15-1.30 p<0.0001) (**Figure 2, Table S3**). The results of the landmark analysis performed at a 5 year cut-off point for patients without MetS according to obesity status is presented in **Figure S1.**

Similar results were obtained for men and women (Figure 3 and 4) and for all age groups except for young adults and late elderly were there were no significant differences in mortality in long-term follow-up (**Figures S2-S7**).

Long term outcome in patients with MetS across BMI categories

Among patients with MetS (NCEP/ATPIII criteria), lean patients (BMI <25 kg/m^2) had worse long-term outcome as compared to overweight (BMI 25-30 kg/m^2) and obese (>30 kg/m^2). individuals (HR – 1.36, 95% CI – 1.16 – 1.61, p =0.0001 and HR – 1.31, 95%CI – 1.12-1.53, p = 0.0008 respectively) (**Figure 2C**). Lean patients with MetS diagnosed according to JIS had less favorable prognosis as compared to overweight (HR – 1.13, 95%CI – 0.99-1.3, p=0.05), but not to obese individuals (HR – 1.05, 95% CI 0.92-1.19, p=0.49) (Figure 2D).

DISCUSSION

The results of this cohort study show that MetS is present in a third of primary care patients in Poland and is more common in women, older and less educated patients. Second, MetS is associated with higher risk of all-cause death in both obese and non-obese people and the magnitude of long-term risk is similar in these both groups. Third, obese subjects without MetS also have a greater risk of death than their non-obese counterparts.

The prevalence of MetS ranges from 13-43% in European countries [32,33], with an average of 24.3% (NCEP/ATP III criteria), which is lower than in our population.[32] Those differences can be partly explained by difference in age between study participants as well as the fact that

the prevalence of MetS is constantly increasing.[34] The incidence of MetS, depends not only on the region, but also on the definition of MetS used in the study. [35–37] Heverinen et al. showed that using different MetS definitions led to different estimates of prevalence, ranging from 18-43%.[38] Regardless of the definition used, the prevalence of MetS in our population, although high, is consistent with data from other epidemiological studies conducted in our country.[39] As in other studies[40] we also observed an increase in the prevalence of MetS and a greater proportion of people with MetS in rural residents and those with primary and vocational education. However, the differences related to the place of residence were smaller than in other countries.[41–43]

Non-obese patients with MetS had similarly unfavorable long-term prognosis as patients with BMI ≥30 kg/m^2 and/or with central obesity. This was true regardless of MetS definition used, and was the same for women and men and for all age groups. Obese patients without MetS had a similar 5-year prognosis as their non-obese counterparts. This is in line with possible early follow-up bias reported in some epidemiologic studies examining the association between obesity and mortality.[6] However, importantly, our analysis similarly to other analyses with long term follow-up[5–7], demonstrated that during a median follow-up of 15 years, mortality rate in this group of patients was significantly higher and got closer to that observed in patients with MetS. This might be due to the fact that obesity without MetS is not a stable phenotype and progresses to MetS over time[44], which was also pointed out in the recent ESC guidelines on cardiovascular disease prevention.[45] In the previous analysis, we demonstrated that metabolome of so called metabolically healthy obese patients resembles that of obese patients with MetS.[46] Therefore, we are the opinion that the term metabolically healthy obesity is not appropriate and may undermine the importance of body weight

reduction in subject not fulfilling MetS criteria. We believe that it is worth considering replacing it with other term in official documents regarding cardiovascular prevention[45].

When stratified according to BMI categories, worst prognosis was observed for lean patients (MetS/NCEP ATP III criteria) or as unfavorable as in patients with BMI $\geq$ 30 (JIS criteria). Every 12th patient with MetS (defined by the NCEP/ATP III and JIS criteria) in our population, had a BMI <25 kg/m^2. At the same time, in publications that define MetS regardless of WC or BMI, the combined presence of at least two of the abnormalities characteristics of MetS (carbohydrate and lipid metabolism disorders or increased blood pressure values) was found in nearly 25% to over 37% of normal weight individuals[16,47–49]. Recent ESC guidelines on cardiovascular disease prevention recommend screening for MetS in all individuals, regardless of their BMI.[45] The diagnosis of MetS in a lean person, requires however the coexistence of increased blood pressure, abnormalities in lipid and carbohydrate metabolism, and in an obese person diagnosis of MetS requires only two of these factors. Therefore it remains an open question whether the currently used criteria are sensitive enough for the diagnosis of MetS in lean individuals. Our analysis showed that applying JIS definition instead of NCEP/ATP III criteria led to 75% increase in percentage of patients diagnosed with MetS among lean individuals, as more lean patients fulfilled WC criterion. Despite this in the group of patients with WC values smaller than cut-off values according to JIS criteria, 1399 (25.5%) men and 815 (14.1%) women still fulfilled at least two criteria for MetS. Nonetheless in this in this subgroup of patients only 496 (4.4%) could be diagnosed with MetS. Differences in clinical characteristics may at least partially account for such high mortality in the lean MetS group. In particular, in this group of patients, there was a higher percentage of smokers and higher levels of LDL-C and TG, with significantly less frequent use of statins and fibrates. Less frequent use of lipid-lowering drugs may be due to the fact that a lean person appears

healthier and consequently, physicians may be less likely to prescribe pharmacological treatment for hypercholesterolaemia.[50] The poor prognosis of patients with MetS, whether they are lean, overweight or obese, is primarily due to the pathophysiology of MetS, which includes insulin resistance, chronic systemic inflammation[51] oxidative stress, an increased thrombotic tendency that aggravates metabolic disorders and accelerated progression of atherosclerotic disease. [52,53] The quality and caloric value of the diet is also important. In a recent analysis of a different patient population, we showed that the Western diet contributes to the development of MetS regardless of BMI.[54]

Study strengths and limitations. The main strength of this study is the inclusion of a large number of patients and very long-term follow-up. To our knowledge few studies have explored the area of MetS in such a large population. Importantly, patients involved in the study were recruited from all 16 regions of Poland and were representative of the population of primary health care. At this level of care, MetS should be diagnosed and treated. Another strength of the study is the fact that all the biochemical analyses were conducted in a central laboratory, which conforms with all the required quality control standards and ensures reliability of the test results. Data on the medical history and office measurements were collected by doctors who knew the patients and looked after them on a daily basis. In 2004 and 2006, the data gathered was the same, but in 2015 was extended to include blood pressure, heart rate and blood glucose.

A limitation of the study is that it was conducted in only one country. We also do not have data on other factors that might influence long term prognosis such as lipoprotein a. Primary healthcare practices were selected at random, but physicians enrolled patients consecutively. Moreover, we did not gain access to data on the causes of deaths of patients and, therefore, conducted our analysis based on all-cause deaths. Data on glucose levels and blood pressure

were available only for patients recruited in 2015. For patients recruited in 2004 and 2006 the diagnosis of MetS was based on lipid measurements, waist circumference, and the presence of hypertension and or diabetes. However, the results of the analysis carried out on in the group of patients recruited in LIPDIOGRAM 2015 edition were similar to those from earlier years (**Figure 8A and S8B**).

In conclusions, MetS is associated with elevated long term mortality risk in both non-obese and obese patients. Lean patients with MetS, despite having more severe metabolic disorders, are less often treated with lipid-lowering drugs. Both physicians and patients should be aware of MetS in lean subjects and should initiate appropriate therapy including behavioral changes and drug treatment. Obesity remains significantly associated with increased mortality risk in patients not fulfilling MetS criteria, therefore the concept of metabolically healthy obesity should be revised.

ACKNOWLEDGMENT:

Funding: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The present study was an initiative of the Polish Lipid Association (PoLA) and the College of Family Physician in Poland (CFPiP). The present study was funded by an unrestricted educational grant from Valeant (Warsaw, Poland). Valeant had no role in study design, data analysis, data interpretation, or writing of the report.

Declaration of conflicting interests: The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Jacek J. Jóźwiak and Maciej Banach have received an unrestricted educational grant from Valeant and has served as a consultant or speaker for Valeant. Peter E. Penson owns 4 shares in AstraZeneca PLC and has received honoraria and/or travel reimbursement for events sponsored by AKCEA, Amgen, AMRYT, Link Medical, Mylan, Napp, Sanofi. All other authors

declare no conflicts of interest concerning the results of this analysis. All authors revised the article critically for important intellectual content. All authors gave final approval of the work have participated sufficiently in the work and take public responsibility for appropriate portions of the content.

Data Availability: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval: Research involving human subjects complied with all relevant national regulations, institutional policies and is in accordance with the tenets of the Helsinki Declaration (as revised in 2013), and has been approved by the Bioethical Committee of the Chamber of Physicians (No.K.B.Cz.-0018/2015).

Authorship: JJ, MB, KO, TO contributed to the conception and design of the work. JJ, MB, AW, TT, MG, MM, KJ contributed to the acquisition and interpretation of data. TO ,JJ, MB, KO drafted the manuscript. TO, MG contributed to analysis and interpretation of data, AK, PP, GL, DM, PT, AC, KR, GH, MT, FC, NS, BW, TM critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

REFERENCES:

1. Dai Id H, Id TAA, Chalghaf Id N, Id MR, Bragazzi NL, Wu J. The global burden of disease attributable to high body mass index in 195 countries and territories, 1990-2017: An analysis of the Global Burden of Disease Study. 2020.
2. WHO EUROPEAN REGIONAL OBESITY REPORT 2022. 2022.
3. Pi-Sunyer FX. The obesity epidemic: pathophysiology and consequences of obesity. *Obes Res* 2002;10 Suppl 2.
4. Poirier P, Giles TD, Bray GA, Hong Y, Stern JS, Pi-Sunyer FX, et al. Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss: an update of the 1997 American Heart Association Scientific Statement on Obesity and Heart Disease from the Obesity Committee of the Council on Nutrition, Physical Activity, and Metabolism. *Circulation* 2006;113:898–918.
5. Flegal KM, Kit BK, Orpana H, Graubard BI. Association of All-Cause Mortality With Overweight and Obesity Using Standard Body Mass Index Categories A Systematic Review and Meta-analysis
6. Aune D, Sen A, Prasad M, Norat T, Janszky I, Tonstad S, et al. BMI and all cause mortality: Systematic review and non-linear dose-response meta-analysis of 230 cohort studies with 3.74 million deaths among 30.3 million participants. *BMJ (Online)*.
7. Xu H, Cupples LA, Stokes A, Liu CT. Association of Obesity With Mortality Over 24 Years of Weight History: Findings From the Framingham Heart Study. *JAMA Netw Open* 2018;1:e184587.
8. Einhorn D, Reaven GM, Cobin RH, Ford E, Ganda OP, Handelsman Y, et al. American College of Endocrinology position statement on the insulin resistance syndrome. *Endocr Pract* 2003;9:237–252.
9. Cleeman JI. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA* 2001;285:2486–2497.
10. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and Management of the Metabolic Syndrome. *Circulation* 2005;112:2735–2752.
11. Alberti KGMM, Zimmet P, Shaw J, George : K, Alberti MM, Aschner P, et al. Metabolic syndrome—a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabetic Medicine* 2006;23:469–480.
12. Grundy SM, Brewer HB, Cleeman JI, Smith SC, Lenfant C. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation* 2004;109:433–438.
13. Balkau B, Charles MA. Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). *Diabet Med* 1999;16:442–443.
14. Alberti KGMM, Zimmet P, Shaw J. The metabolic syndrome--a new worldwide definition. *Lancet* 2005;366:1059–1062.
15. Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation;

International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation* 2009;120:1640–1645.
16. Buscemi S, Chiarello P, Buscemi C, Corleo D, Massenti MF, Barile AM, et al. Characterization of Metabolically Healthy Obese People and Metabolically Unhealthy Normal-Weight People in a General Population Cohort of the ABCD Study. *J Diabetes Res* 2017;2017.
17. Cefalu WT, Bray GA, Home PD, Garvey WT, Klein S, Pi-Sunyer FX, et al. Advances in the science, treatment, and prevention of the disease of obesity: Ref lections from a diabetes care editors' expert forum. *Diabetes Care* 2015;38:1567–1582.
18. Sanyal D. Lean metabolic syndrome: An emerging concept. *Indian Journal of Endocrinology and Metabolism*.
19. Ruderman NB, Schneider SH, Berchtold P. The 'metabolically-obese,' normal-weight individual. *Am J Clin Nutr* 1981;34:1617–1621.
20. Gadekar T, Dudeja P, Basu I, Vashisht S, Mukherji S. Correlation of visceral body fat with waist–hip ratio, waist circumference and body mass index in healthy adults: A cross sectional study. *Med J Armed Forces India* 2020;76:41–46.
21. Shah R v., Murthy VL, Abbasi SA, Blankstein R, Kwong RY, Goldfine AB, et al. Visceral adiposity and the risk of metabolic syndrome across body mass index: The MESA study. *JACC Cardiovasc Imaging* 2014;7:1221–1235.
22. Mottillo S, Filion KB, Genest J, Joseph L, Pilote L, Poirier P, et al. The metabolic syndrome and cardiovascular risk: A systematic review and meta-analysis. *J Am Coll Cardiol* 2010;56:1113–1132.
23. Succurro E, Marini MA, Frontoni S, Hribal ML, Andreozzi F, Lauro R, et al. Insulin secretion in metabolically obese, but normal weight, and in metabolically healthy but obese individuals. *Obesity (Silver Spring)* 2008;16:1881–1886.
24. Romero-Corral A, Somers VK, Sierra-Johnson J, Korenfeld Y, Boarin S, Korinek J, et al. Normal weight obesity: a risk factor for cardiometabolic dysregulation and cardiovascular mortality. *Eur Heart J* 2010;31:737–746.
25. Hyun YJ, Koh SJ, Chae JS, Kim JY, Kim OY, Lim HH, et al. Atherogenecity of LDL and unfavorable adipokine profile in metabolically obese, normal-weight woman. *Obesity (Silver Spring)* 2008;16:784–789.
26. Meigs JB, Wilson PWF, Fox CS, Vasan RS, Nathan DM, Sullivan LM, et al. Body mass index, metabolic syndrome, and risk of type 2 diabetes or cardiovascular disease. *J Clin Endocrinol Metab* 2006;91:2906–2912.
27. Kaess BM, Jóźwiak J, Nelson CP, Lukas W, Mastej M, Windak A, et al. The Relation of Rapid Changes in Obesity Measures to Lipid Profile - Insights from a Nationwide Metabolic Health Survey in 444 Polish Cities. Uversky VN, ed. *PLoS One* 2014;9:e86837.
28. Jóźwiak J, Kasperczyk S, Tomasik T, Osadnik T, Windak A, Studziński K, et al. Design and rationale of a nationwide screening analysis from the LIPIDOGRAM2015 and LIPIDOGEN2015 studies. *Archives of Medical Science* 2020.
29. Mancia G, Fagard R, Narkiewicz K, Redon J, Zanchetti A, Bohm M, et al. 2013 ESH/ESC Guidelines for the management of arterial hypertension: the Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *J Hypertens* 2013;31:1281–1357.

30. Franssen T, Stijnen M, Hamers F, Schneider F. Age differences in demographic, social and health-related factors associated with loneliness across the adult life span (19-65 years): a cross-sectional study in the Netherlands. *BMC Public Health* 2020;20:1118.
31. Orimo H, Ito H, Suzuki T, Araki A, Hosoi T, Sawabe M. Reviewing the definition of 'elderly'. *Geriatr Gerontol Int* 2006;6:149–158.
32. Scuteri A, Laurent S, Cucca F, Cockcroft J, Cunha PG, Mañas LR, et al. Metabolic syndrome across Europe: different clusters of risk factors. *Eur J Prev Cardiol* 2015;22:486–491.
33. Farsang C, Naditch-Brule L, Perlini S, Zidek W, Kjeldsen SE. Inter-regional comparisons of the prevalence of cardiometabolic risk factors in patients with hypertension in Europe: the GOOD survey. *J Hum Hypertens* 2009;23:316–324.
34. Saklayen MG. The Global Epidemic of the Metabolic Syndrome. *Curr Hypertens Rep* 2018;20.
35. Waterhouse DF, McLaughlin AM, Sheehan F, O'Shea D. An examination of the prevalence of IDF- and ATPIII-defined metabolic syndrome in an Irish screening population. *Ir J Med Sci* 2009;178:161–166.
36. Qiao Q, Pitkäniemi J, Tuomilehto J, Gao WG, Pyörälä K, Balkau B, et al. Comparison of different definitions of the metabolic syndrome in relation to cardiovascular mortality in European men and women. *Diabetologia* 2006;49:2837–2846.
37. Nilsson PM, Engström G, Hedblad B. The metabolic syndrome and incidence of cardiovascular disease in non-diabetic subjects--a population-based study comparing three different definitions. *Diabet Med* 2007;24:464–472.
38. Haverinen E, Paalanen L, Palmieri L, Padron-Monedero A, Noguer-Zambrano I, Sarmiento Suárez R, et al. Comparison of metabolic syndrome prevalence using four different definitions – a population-based study in Finland. *Archives of Public Health* 2021;79.
39. Micek A, Grosso G, Polak M, Kozakiewicz K, Tykarski A, Puch Walczak A, et al. International Journal of Food Sciences and Nutrition Association between tea and coffee consumption and prevalence of metabolic syndrome in Poland-results from the WOBASZ II study (2013-2014) Association between tea and coffee consumption and prevalence of metabolic syndrome in Poland-results from the WOBASZ II study (2013-2014). *Int J Food Sci Nutr* 2013;69:358–368.
40. Moore JX, Chaudhary N, Akinyemiju T. Metabolic syndrome prevalence by race/ ethnicity and sex in the united states, national health and nutrition examination survey, 1988-2012. *Prev Chronic Dis* 2017;14.
41. Misra A, Khurana L. Obesity and the metabolic syndrome in developing countries. *J Clin Endocrinol Metab* 2008;93.
42. Alves L, Azevedo A, Silva S, Barros H. Socioeconomic inequalities in the prevalence of nine established cardiovascular risk factors in a southern European population. *PLoS One* 2012;7.
43. Mackenbach JP, Stirbu I, Roskam A-JR, Schaap MM, Menvielle G, Leinsalu M, et al. Socioeconomic inequalities in health in 22 European countries. *N Engl J Med* 2008;358:2468–2481.
44. Mongraw-Chaffin M, Foster MC, Anderson CAM, Burke GL, Haq N, Kalyani RR, et al. Metabolically Healthy Obesity, Transition to Metabolic Syndrome, and Cardiovascular Risk. *J Am Coll Cardiol* 2018;71:1857–1865.

45. Visseren FLJ, MacH F, Smulders YM, Carballo D, Koskinas KC, Bäck M, et al. 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. *European Heart Journal*.
46. Osadnik K, Osadnik T, Bieg T, Lejawa M, Fronczek M, Gasior M, et al. Abstract 13796: 1Hnmr Spectroscopy Reveals Only Subtle Differences Between Serum Metabolome of Metabolically Healthy Obese Subjects and Subjects With Metabolic Syndrome. *Circulation* 2019;140:A13796–A13796.
47. Marques-Vidal P, Pécoud A, Hayoz D, Paccaud F, Mooser V, Waeber G, et al. Normal weight obesity: relationship with lipids, glycaemic status, liver enzymes and inflammation. *Nutr Metab Cardiovasc Dis* 2010;20:669–675.
48. Lorenzo A de, Gobbo V del, Premrov MG, Bigioni M, Galvano F, Renzo L di. Normal-weight obese syndrome: early inflammation? *Am J Clin Nutr* 2007;85:40–45.
49. Wildman RP, Muntner P, Reynolds K, McGinn AP, Rajpathak S, Wylie-Rosett J, et al. The obese without cardiometabolic risk factor clustering and the normal weight with cardiometabolic risk factor clustering: prevalence and correlates of 2 phenotypes among the US population (NHANES 1999-2004). *Arch Intern Med* 2008;168:1617–1624.
50. Ferrières J, Lautsch D, Gitt AK, Ferrari G de, Toplak H, Elisaf M, et al. Body mass index impacts the choice of lipid-lowering treatment with no correlation to blood cholesterol - Findings from 52 916 patients in the Dyslipidemia International Study (DYSIS). *Diabetes Obes Metab* 2018;20:2670–2674.
51. Ellulu MS, Patimah I, Khaza'ai H, Rahmat A, Abed Y. Obesity and inflammation: the linking mechanism and the complications. *Arch Med Sci* 2017;13:851.
52. Jakubiak GK, Osadnik K, Lejawa M, Osadnik T, Goławski M, Lewandowski P, et al. 'Obesity and Insulin Resistance' Is the Component of the Metabolic Syndrome Most Strongly Associated with Oxidative Stress. *Antioxidants (Basel)* 2021;11.
53. Jakubiak GK, Osadnik K, Lejawa M, Kasperczyk S, Osadnik T, Pawlas N. Oxidative Stress in Association with Metabolic Health and Obesity in Young Adults. *Oxid Med Cell Longev* 2021;2021.
54. Osadnik K, Osadnik T, Lonnie M, Lejawa M, Reguła R, Fronczek M, et al. Metabolically healthy obese and metabolic syndrome of the lean: the importance of diet quality. Analysis of MAGNETIC cohort

Table 1. Definition of metabolic syndrome.

Parameter	Cut-offs
Central obesity (NCEP/ATP III)	WC ≥102 cm in men and ≥88 cm in women
Central obesity (2009 JIS)	WC ≥94 cm in men and ≥80 cm in women*
Blood Pressure	SBP ≥130 mmHg or DBP ≥85 mmHg Or use of antihypertensive medication
Triglycerides	≥150 mg/dl (1.7 mmol/l) Or use of triglyceride lowering medication (e.g., fibrate or nicotinic acid or high dose omega-3 fatty acids**)
HDL cholesterol	Men <40 mg/dl (1.0 mmol/l), Women <50 mg/dl (1.3 mmol/l) or use fibrate or nicotinic acid
Glucose	≥ 100 mg/dl (5.6 mmol/l) or diabetes mellitus type 2
	0-1 of the above criteria
Metabolic Syndrome diagnosis	≥3 of the above criteria

*WC – waist circumference, SBP – systolic blood pressure, DBP – diastolic blood pressure, MetS – metabolic syndrome, NCEP/ATP III – National Cholesterol Education Program/Adult Treatment Panel III, JIS – Joint Interim Statement. * For triglyceride lowering drugs we had information only on fibrates. Nicotinic acid was never available in Poland. ** WC cut-offs for Caucasians.*

Table 2. Clinical characteristics of the study population and patients with MetS* according to NCEP/ATP III criteria and JIS criteria.

Values in tables are given as means (standard deviation) or numbers (%).

Comparison of clinical characteristics between patients with MetS *vs* without Mets is shown in Table S1.

	Whole population (n=45 615)	MetS NCEP/ATP III (n=14 202)	MetS JIS (n=17 216)
Age (years)	56.3 (11.8)	59.9 (10.8)	59.4 (10.9)
Females	28150 (61.7)	9173 (64.6)	10645 (61.8)
Secondary/higher education	26031 (57.1)	6689 (47.1)	8421 (48.9)
Urban place of residence	25266 (55.4)	7536 (53.1)	9625 (54.1)
Obesity	24203 (53.1)	12 812 (90.2)	13 365 (77.6)
Central obesity	22093 (48.4)	12 477 (87.9)	12 477 (72.5)
BMI [kg/m^2]	28.3 (4.8)	31.4 (4.6)	30.7 (4.6)
WC [cm] women	89.8 (13.4)	99.6 (11.2)	97.3 (11.9)
men	98.6 (11.5)	107.6 (10.7)	105.3 (10.3)
Diabetes mellitus	5692 (12.5)	4500 (31.7)	4947 (28.7)
Hypertension	23509 (51.5)	11 543 (81.3)	13 751 (79.9)
Previous MI	2707 (5.9)	1086 (7.6)	1328 (7.7)
Dyslipidemia	22490 (49.3)	8541 (60.1)	10 219(59.4)
Current smoker	8622(18.9)	2273 (16.0)	2878 (16.7)
Physical activity	9175 (30.8)	3304 (29.2)	3992 (29.6)
Statin	13037 (28.6)	5474 (38.5)	6471 (37.6)
Fibrate	1595 (3.5)	771 (5.4)	908 (5.3)
SBP [mmHg]*	132 (18.5)	139 (18.1)	138 (17.9)
DBP [mmHg]*	78 (10.2)	82 (10.5)	83 (10.5)
TC [mg/dl]	215 (45)	212(48)	213 (48)
LDL-C [mg/dl]	129 (38)	128 (40)	129 (40)
HDL-C [mg/dl] Women	63 (15)	53 (12)	54 (13)
Men	54 (14)	45 (11)	47 (12)
TG [mg/dl]	147 (86)	196 (111)	192 (107)
Glucose* [mg/dl]	103 (25)	114 (29)	112 (28)

**Data available for patients recruited in 2015. BMI – body mass index, WC – waist circumference, MI – myocardial infarction, SBP – systolic blood pressure, DBP – diastolic blood pressure. TC – total cholesterol, LDL-C – low density lipoprotein cholesterol NCEP/ATP III - National Cholesterol Education Program, Adult Treatment Panel III. JIS – Joint Interim Statement.*

Table 3. Mortality risks according to diagnosis of MetS and presence of obesity during follow-up period.

	Obese* patients with MetS	Non-Obese patients with MetS	Obese* patients without MetS	Non-obese patients without MetS
NCEP/ATP IIII definition				
Mortality risk – 5 years	747/12 560 (5.9%)	92/1367 (6.7%)	379/11 164 (3.4%)	691/19 529 (3.5%)
Mortality risk – 15 years*	2553/12 560 (20.3%)	258/1367 (18.9%)	1929/11 164 (17.3%)	2819/19 529 (14.4%)
JIS definition				
Mortality risk – 5 years	765/13 106 (5.8%)	200/3778 (5.3%)	361/10 618 (3.4%)	583/17 118 (3.4%)
Mortality risk – 15 years*	2642/13 106 (20.2%)	675/3778 (17.9%)	1840/10 618 (17.3)	2402/17 118 (14.0%)

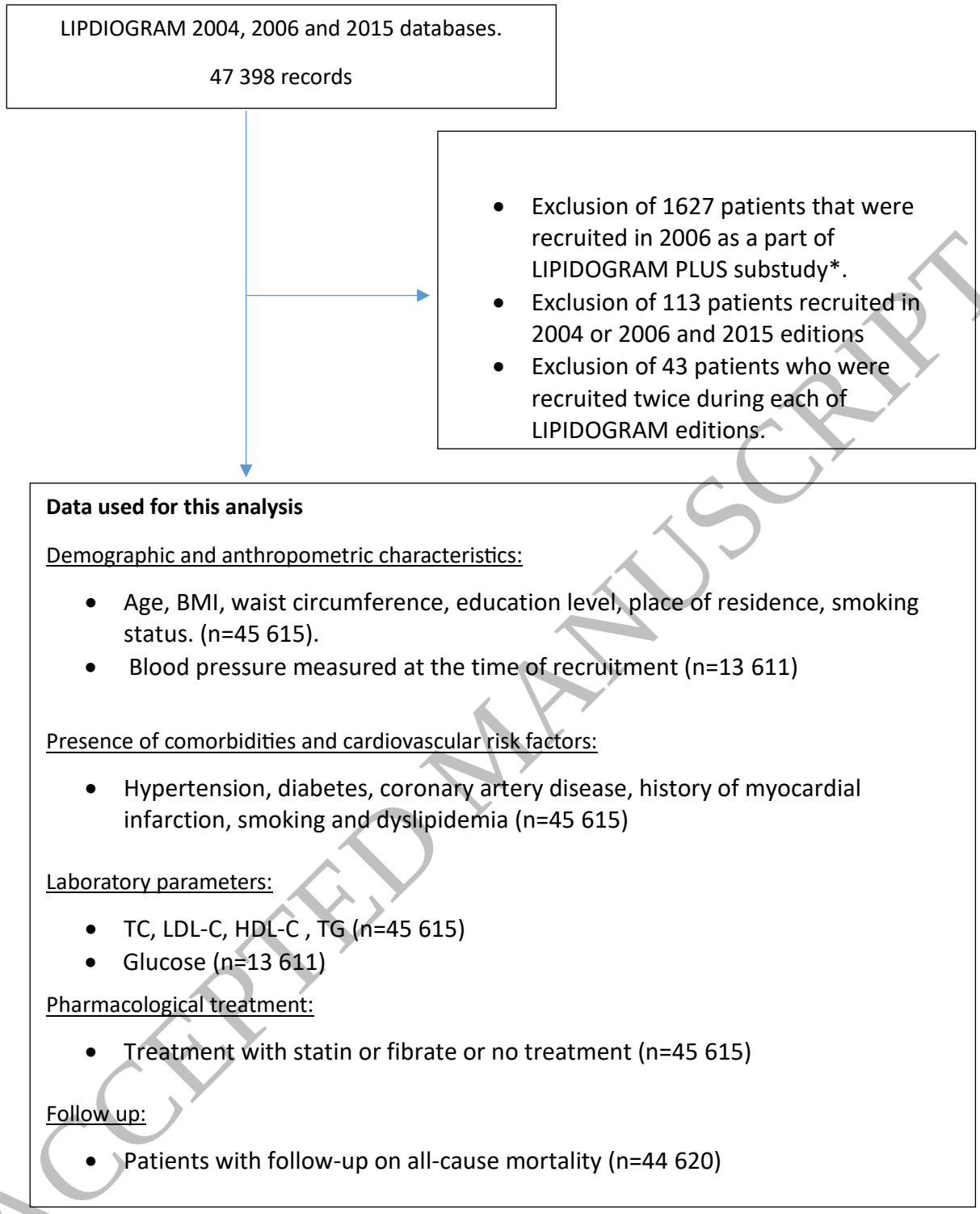
*MetS – Metabolic Syndrome, NCEP/ATP III - National Cholesterol Education Program, Adult Treatment Panel III, JIS – Joint Interim Statement. Results are given as death count/number of patients in the given group. *Refers to median follow-up.* Patients with BMI* $\geq$ 30 kg/m^2, or central obesity.

Table 4. Clinical characteristics of patients with MetS according to BMI categories.

	MetS (NCEP/ATP III) n = 14 202			MetS (JIS) n = 17 216		
	Lean n=804	**Overweight n =4947**	**Obese n=8451**	**Lean n=1409**	**Overweight n=6803**	**Obese n=9004**
Age	61.3 (12.1)	60.8 (11.1)	59.2 (10.5)	60.4 (11.9)	59.9 (10.6)	58.9 (11.1)
Females	620 (77.1)	3319 (67.1)	5234 (61.9)	1102 (78.2)	4176 (59.6)	5367 (61.4)
BMI [kg/m^2]	23.3 (1.6)	27.9 (1.4)	34.2 (3.6)	23.34 (1.5)	27.73 (1.4)	34.06 (3.6)
Diabetes	211 (26.2)	1355 (27.4)	2934 (34.7)	288 (20.4)	1628 (23.9)	3031 (33.7)
Hypertension	575 (71.5)	3873 (78.3)	7095 (84.0)	975 (69.2)	5230 (76.8)	7546 (83.8)
Previous MI	55 (6.8)	396 (8.0)	635 (7.5)	89 (6.3)	564 (8.3)	675 (7.5)
Dyslipidemia	456 (56.7)	2964 (60.0)	5121 (60.6)	786 (55.8)	3999 (58.8)	5434 (60.4)
Current smoker	204 (25.4)	836 (16.9)	1233 (14.6)	355 (25.2)	1196 (17.6)	1327 (14.7)
Physical activity	204 (29.7)	1245 (31.2)	1855 (28.1)	344 (29.8)	1677 (31.4)	1971 (28.2)
Statin	277 (34.5)	1895 (38.3)	3302 (39.1)	462 (32.8)	2510 (36.9)	3499 (38.8)
Fibrate	39 (4.7)	259 (5.2)	473 (5.6)	54 (3.8)	352 (5.2)	502 (5.6)
TC [mg/dl]	219219 (52)	213 (47)	210 (47)	220 (51)	215 (48)	210.6 (47.1)
LDL-C [mg/dl]	134 (45)	130 (41)	127 (40)	135 (44)	131 (41)	127.0 (39.5)
HDL-C Women	54 (14)	53 (13)	53 (12)	56 (142)	55 (13)	53 (12)
[mg/dl] Men	43 (12)	45 (12)	45 (11)	48 (14)	48 (12)	46 (11)
TG [mg/dl]	208208 (176)	192 (92)	197 (114)	188 (142)	187 (89)	197 (112)
Glucose [mg/dl]	110 (24)	110 (24)	116 (32)	107 (23)	109 (24)	116 (32)

BMI – body mass index, MI – myocardial infarction, TC – total cholesterol, LDL-C – low density lipoprotein cholesterol. NCEP/ATP III - National Cholesterol Education Program/Adult Treatment Panel III. JIS – Joint Interim Statement. Values in tables are given as means (standard deviation) or numbers (%).

Figure 1. Study flow-chart



*BMI – body mass index, TC – total cholesterol, LDL-C – low density lipoprotein cholesterol, HDL-C – high density lipoprotein cholesterol, TG – triglycerides. *LIPIODOGRAM PLUS was a planned follow-up of a subset of patients (n=1627) recruited in 2004 and then again in 2006.*

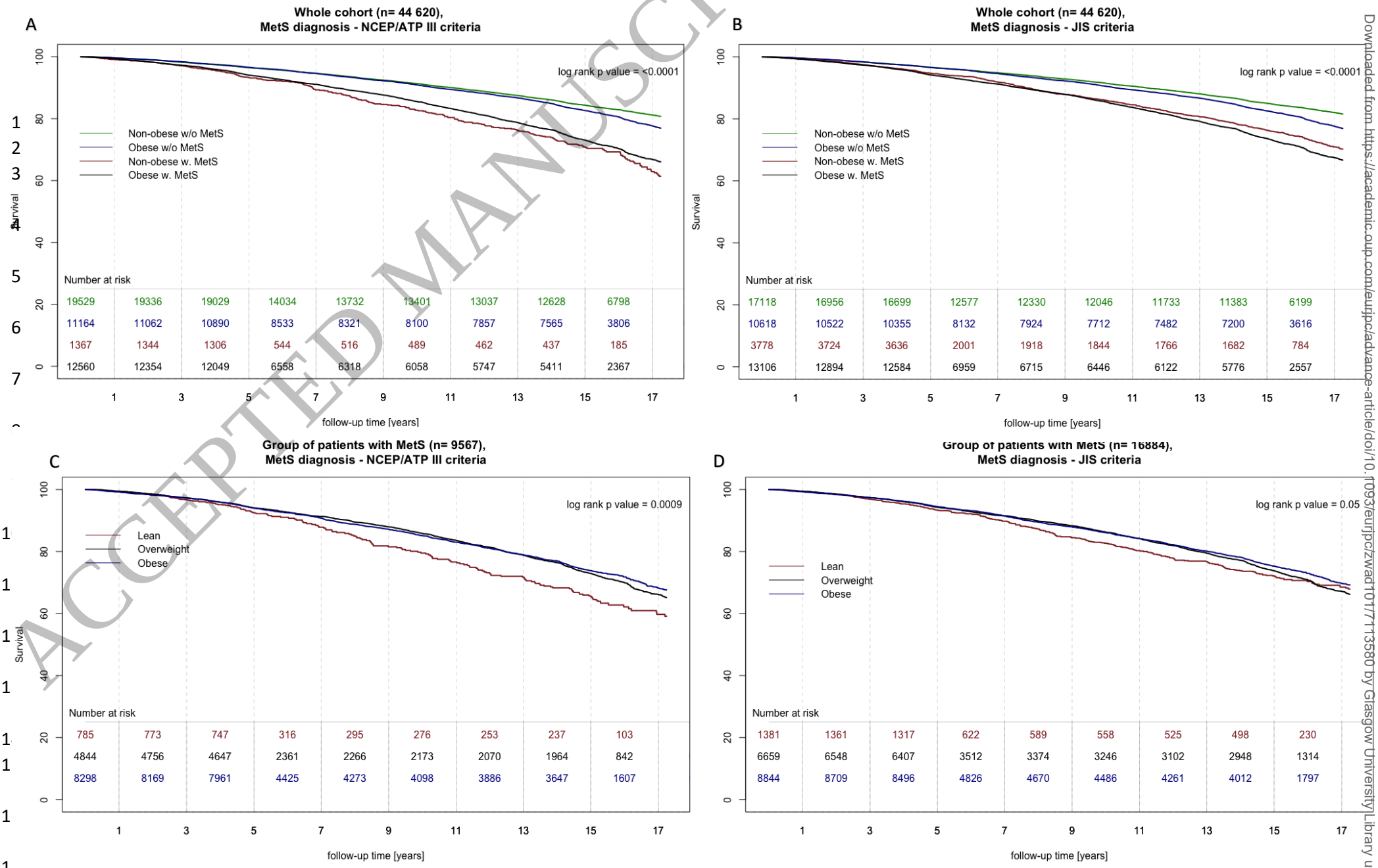
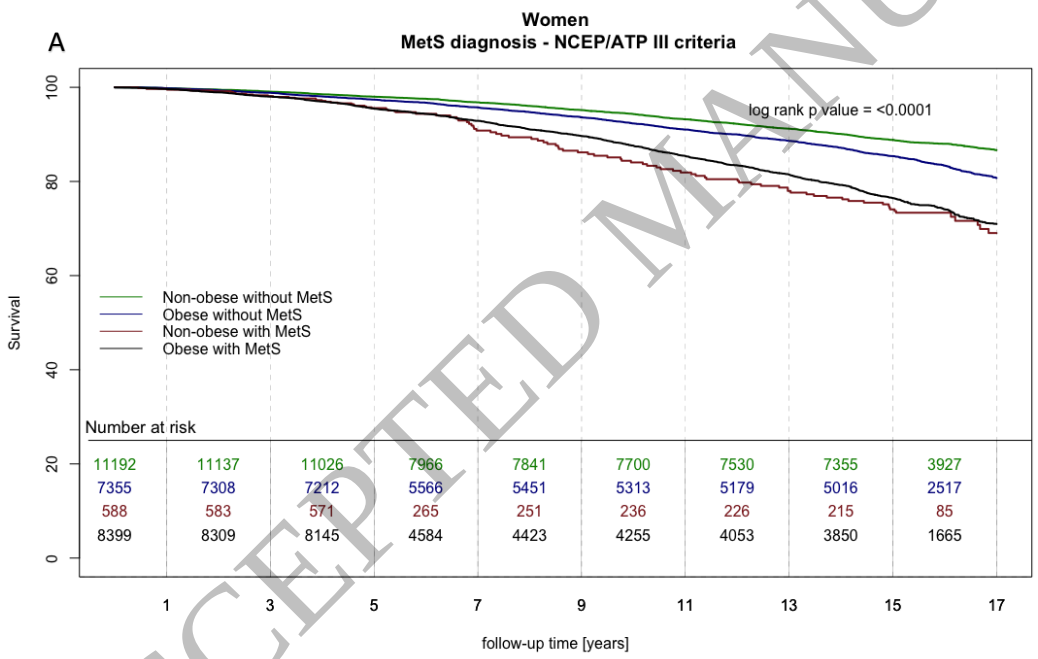


Figure 2. A) Long term outcome in patients with or without MetS (NCEP/ATP III criteria), with respect to obesity. B) Long term outcome in patients with or without MetS (JIS criteria) with respect to obesity. C) Long term outcome in patients with MetS (NCEP/ATPIII) criteria stratified by BMI categories. D) Long term outcome in patients with MetS (JIS criteria) stratified by BMI categories. NCEP/ATP III - National Cholesterol Education Program, Adult Treatment Panel III, JIS – Joint interim statemen



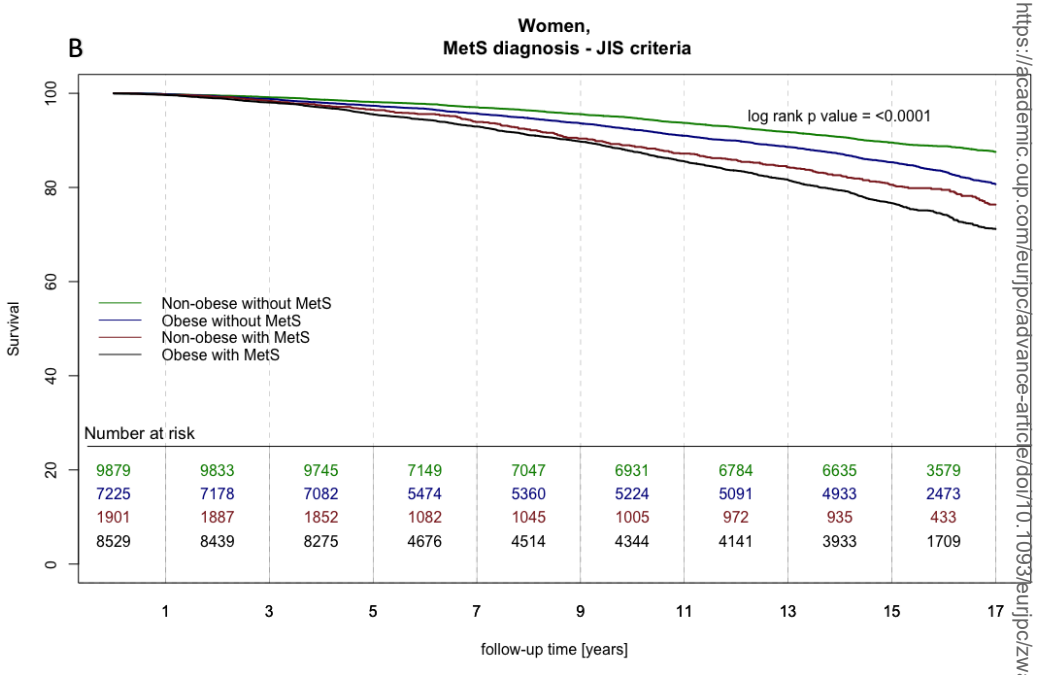


Figure 3. A) Long term outcome in women with or without MetS (NCEP/ATP III criteria), with respect to obesity. B) Long term outcome in women with or without MetS (JIS criteria) with respect to obesity.

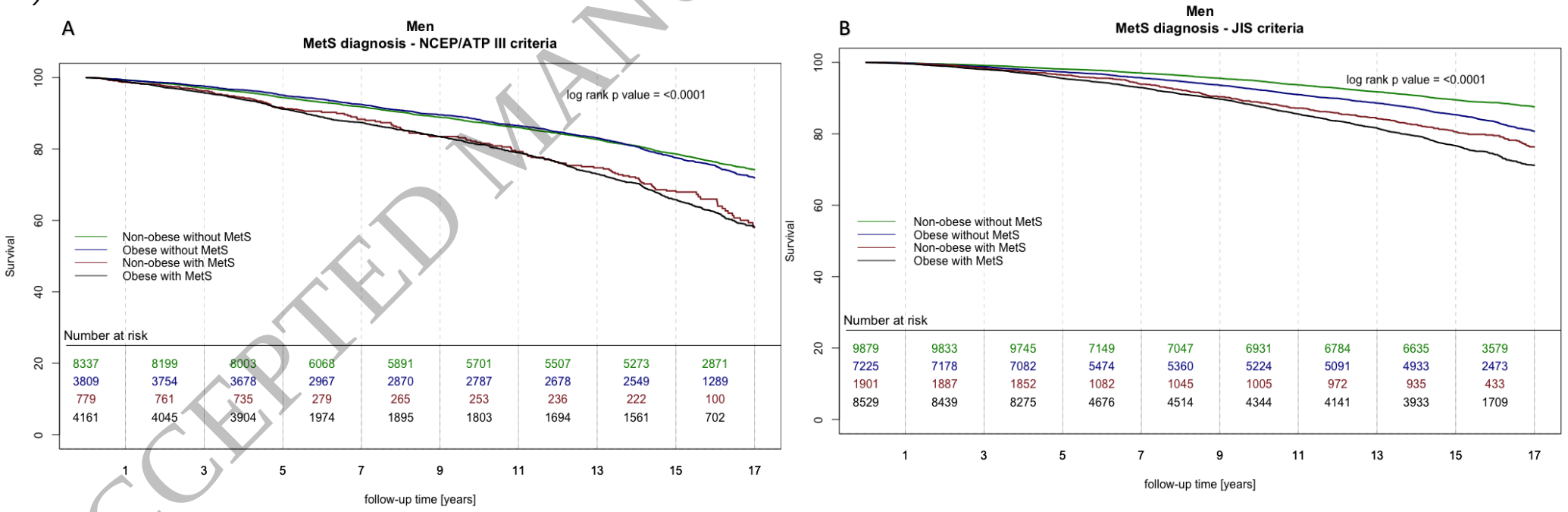


Figure 4. Long term outcome in men with or without MetS (NCEP/ATP III criteria), with respect to obesity. B) Long term outcome in men with or without MetS (JIS criteria) with respect to obesity.