BMI and Frequency of Diabetes, Hypertension, and Dyslipidemia: Comparison of SHIELD and NHANES Data

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Abstract

History, physical and laboratory data from the National Health and Nutrition Examination Survey (NHANES) 1999–2002 demonstrated that increasing body mass index (BMI) is associated with an increasing prevalence of diabetes, hypertension and dyslipidemia. In 2004, a 12-item screener questionnaire (Study to Help Improve Early evaluation and management of risk factors Leading to Diabetes [SHIELD]) was mailed to 200,000 households selected to be representative of the US adult population — the largest such survey of its kind. This self-reported survey was returned by 127,420 households (63.7% response rate) and included height, weight and other data about the recipient and family members (N=211,097), such as if a healthcare professional had ever told them they had diabetes, high blood pressure, or problems with cholesterol. Both studies, upweighted to US adult population, had similar distributions of BMI, with mean (± standard deviation) of 27.8 (±6.8) kg/m^2 for SHIELD (N=211,097) and 27.9 (±6.2) kg/m^2 for NHANES (N=4257). Table shows that metabolic diseases are reported at all BMIs. Both studies showed that an increase in BMI is associated with increased prevalence of diabetes, hypertension and dyslipidemia. The reported prevalence of metabolic diseases was less in SHIELD than NHANES, suggesting selection bias of the two approaches or possibly a lack of knowledge or awareness of metabolic diseases with a self-reported survey.

		% of Patients in Listed BMI Range (kg/m^2) Who Have Listed Comorbidity					
With Comorbidities (% of Population)	**Overall (% Population)**	**18.5–24.9**	**25.0–26.9**	**27.0–29.9**	**30.0–-34.9**	**35.0–39.9**	**≥40**
Diabetes							
SHIELD*	8.2	3.5	6.0	8.1	12.8	18.0	25.1
NHANES*	8.9	4.2	5.7	10.1	12.2	16.4	27.3
Hypertension							
SHIELD*	23.4	13.2	21.4	26.5	34.6	40.5	45.8
NHANES*	28.9	17.6	25.3	30.8	39.3	44.0	51.3
Dyslipidemia							
SHIELD*	25.8	17.9	27.7	31.2	34.8	35.9	35.9
NHANES*	52.9	38.2	53.1	62.2	68.0	67.5	62.5
Any of the conditions							
SHIELD*	38.9	26.2	39.3	45.1	52.6	57.5	62.1
NHANES*	62.3	45.9	62.9	70.3	78.2	81.1	77.0
All 3 conditions							
SHIELD*	3.3	0.9	2.0	3.1	5.8	8.4	11.6
NHANES*	2.7	1.2	0.5	3.8	3.3	6.6	7.6

*p<0.001 (test for linear trend across BMI groups)

Introduction

- Although the relationship between obesity and the increasing prevalence of diabetes, hypertension, and dyslipidemia is well established,[1] a thorough and detailed description of the relationship of BMI categories to metabolic diseases is not easily accessible in the published literature.
- Given the recognized health burden,[2] it is surprising that the co-prevalence of obesity and metabolic diseases has not been more precisely defined.
- In this analysis, data from two national studies (SHIELD and NHANES) were evaluated to determine the relationship of different BMI categories and the prevalence of diabetes, hypertension, and dyslipidemia, as well as the levels of BMI associated with each of these metabolic diseases.

Objectives

- Explore the relation between BMI level and prevalence of diabetes, hypertension, and dyslipidemia
- Examine the distribution of BMI levels among those with each of these conditions
- Compare the results on these measures between the two national surveys (SHIELD and NHANES)

Methods

SHIELD

- As part of the longitudinal SHIELD study, a self-reported survey was used to assess the association of different BMI categories with diabetes, hypertension, and dyslipidemia.
- A screening survey was mailed to a stratified random sample of 200,000 US households (part of the NFO household panel) in April 2004, and 127,420 households returned usable surveys (response rate = 63.7%). The NFO is a market research firm that maintains a survey panel of more than 600,000 households throughout the US, constructed to represent the US population in terms of geographic residence, age of head of household, and household size and income.
- The screener questionnaire consisted of 12 questions developed by a diversified panel of experts (the SHIELD Study Group). The questionnaire was completed by the head of household, who answered for up to 4 adult (≥18 years of age) household members. Therefore, the returns actually contained data on 211,097 adults.
- Judging that respondents to a self-administered questionnaire would be unlikely to recall their actual FPG, BP, or lipid levels, respondents were asked if they had ever been diagnosed as having, or were currently taking prescription medications for diabetes, high BP, or cholesterol problems. Respondents were also asked to provide their weight and height, which were used to calculate BMI. The returned sample (N=211,097) was upweighted to match 2003 US census data on age, gender, and household size.[3]
- Using these responses, a matrix was constructed to compare BMI levels with the prevalence of pre-existing risk factors, as well as to identify the population distribution of BMI levels among individuals with these conditions. For both sets of data, BMI was categorized using cut-points derived from the 1998 NHLBI Guidelines.[4]

NHANES

- Data from SHIELD were compared with similar data from the fourth round of NHANES (1999–2002).[5,6] NHANES produces nationally representative data about the health and nutritional status of the US civilian noninstitutionalized population. NHANES has the added value of including both self-reported risk factors as well as clinical evaluation and laboratory testing to confirm diagnoses and to identify undiagnosed risk factors.
- NHANES data on adults ≥18 years old (N=4257) was analyzed to determine the prevalence of diabetes, hypertension, and dyslipidemia across different BMI ranges. Because the NHANES data includes laboratory values along with diagnoses and treatments, it can be used with a weighting system to estimate actual national prevalence of various conditions.
- Overall prevalence estimates (self-reported plus laboratory-test confirmed) were calculated using NHANES sampling weights based on age, income and race/ethnicity, to represent the US adult population. Standard errors were estimated using SUDAAN® to account for both the complex sample design and the use of both interview and morning examination sample data in combination.[5,7]

Identifying conditions

For SHIELD, diabetes (type 1 and type 2, not gestational), hypertension, and dyslipidemia were identified through self-report that a healthcare professional had diagnosed the condition (i.e., "conditions that you/other adult household members have ever been told you have by a doctor or nurse"). BMI was calculated using self-reported height and weight.

For NHANES, the following definitions were used:

- Diabetes includes both previously diagnosed and undiagnosed diabetes mellitus (type 1 or type 2). Diagnosed diabetes is based on self-report (i.e, answered yes to "Has a doctor ever told you that you have diabetes?"). Undiagnosed diabetes is defined using the criterion of FPG >125 mg/dL.
- Hypertension was defined as either having elevated BP (systolic pressure ≥140 mm Hg or diastolic pressure ≥90 mm Hg) or taking antihypertensive medication. (BP is reported as the average of measurements taken; 78% of participants had 3 BP readings.)
- Dyslipidemia was defined as any of the following: TC ≥240 mg/dL, TG >200 mg/dL, LDL-C ≥160 mg/dL, HDL-C <40 mg/dL. No consideration of CHD risk factors was included in the definition of dyslipidemia.

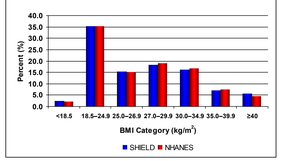
Statistical analysis

- Comparisons of population weight distribution between SHIELD and NHANES were made, with respondents allocated into one of seven categories based on BMI measurements (<18.5, 18.5–24.9, 25.0–26.9, 27.0–29.9, 30.0–34.9, 35.0–35.9, and >40 kg/m^2). Prevalences were calculated for each of the above conditions within these BMI categories. The distribution of BMI categories within each of the disease cohorts was also examined.
- Tests for linear trend were performed using logistic regressions in SUDAAN® release 9.0.[7] These analyses were performed using SUDAAN to ensure proper sample weighting and estimation of variance, reflecting the complex sampling methods used in NHANES.

Results

- Both studies had similar distributions of BMI, with mean (±SD) of 27.8 (±6.8) kg/m^2 for SHIELD and 27.9 (±6.2) for NHANES.

Figure 1. BMI distributions



Relationship of BMI level to prevalence of diabetes, hypertension, and dyslipidemia

Figure 2. Prevalence of diabetes (types 1 and 2) by BMI level*

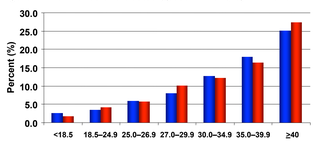


Figure 3. Prevalence of hypertension by BMI level*

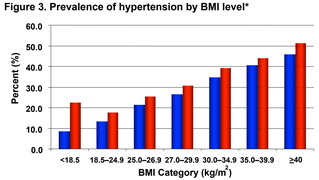
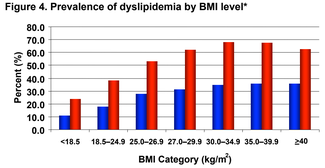


Figure 4. Prevalence of dyslipidemia by BMI level*



*p<0.001 in tests of linear trend across BMI groups within each study (SHIELD and NHANES)

- The estimated prevalences of diabetes and hypertension were similar in the NHANES and SHIELD participants (Figures 2 and 3), although the prevalence of hypertension reported in NHANES was generally slightly higher than in SHIELD.
- The prevalence of dyslipidemia was substantially higher across all BMI levels in NHANES, compared with SHIELD (Figure 4).
- For dyslipidemia, this level of difference was somewhat surprising, given the lack of an aggressive definition of this condition for NHANES. Had a more aggressive definition of dyslipidemia been employed, including LDL-C levels >100mg/dL or >130 mg/dL, this would have been expected to increase the proportion of those respondents with dyslipidemia and, thus, further widen the differences in prevalence between NHANES and SHIELD.
- Most importantly, these data demonstrate that not all overweight or obese patients have diabetes, hypertension, and/or dyslipidemia.
- Both studies demonstrated that these metabolic diseases occurred at all BMI levels, but significantly increased with higher BMI (p<0.001 for each disease in tests for linear trend across BMI groups).

Distribution of BMI levels among those with diabetes, hypertension, and dyslipidemia

Figure 5. BMI of diabetic respondents (types 1 and 2)

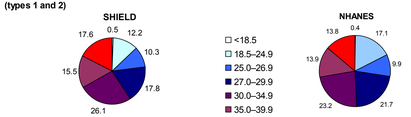


Figure 6. BMI of hypertensive respondents

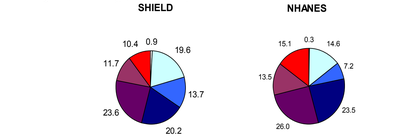
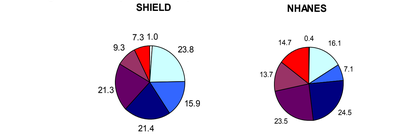


Figure 7. BMI of dyslipidemic respondents



- As can be seen in Figures 5–7, in general, the BMI ranges of patients with diabetes mellitus, hypertension, and dyslipidemia were similar between SHIELD and NHANES. Not all patients with these metabolic diseases were overweight; however, the vast majority were overweight or obese, with a BMI of ≥25 kg/m^2.

Limitations

- The 600,000 households participating in the NFO panel had voluntarily elected to do so, leading to the possibility of bias due to self-selection. However, once this extensive database was established, 200,000 households were mailed screening questionnaires in a randomized fashion with a high return rate of ~64%.
- Household panels also tend to under-represent the very wealthy and very poor segments of the population and do not include military or institutionalized individuals.[8]

Conclusions

- Both studies showed the metabolic diseases of diabetes mellitus, hypertension, and dyslipidemia occur across all ranges of BMI, and that the prevalence of each of these metabolic diseases increases with increasing BMI. It also confirmed that not all patients who are overweight or obese have these metabolic diseases and, conversely, not all patients with these metabolic diseases are overweight or obese.[9]
- With the exception of the prevalence of dyslipidemia, SHIELD was comparable to NHANES in the relationship of BMI and metabolic disease, and metabolic disease to BMI. Because it contains both reported diagnosis and actual laboratory data, the prevalences estimated from the NHANES data are more likely to reflect the true prevalence of (diagnosed and undiagnosed) disease. However, surveys using consumer panels, such as SHIELD, may be a relatively inexpensive and effective method to collect data on many aspects of the relationship of self-reported data and metabolic diseases.

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Abbreviations

BMI = body mass index; BP = blood pressure; CHD = coronary heart disease; FPG = fasting plasma glucose; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; NFO = National Family Opinion; NHANES = National Health and Nutrition Examination Survey; NHLBI = National Heart, Lung and Blood Institute; SHIELD = Study to Help Improve Early evaluation and management of risk factors Leading to Diabetes; TC = total cholesterol; TG = triglycerides

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