危険因子の最新知見

心血管病の危険因子としての喫煙

Smoking is an important risk factor for cardiovascular disease in Japan

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Key words：喫煙，コレステロール，交互作用，メタボリックシンドローム，人口寄与危険割合

はじめに

欧米諸国に比べてアジア諸国における喫煙率はいまだ高く，世界の喫煙者のうち約2/3がアジア環太平洋地域の国民であると報告されている．同時にこの地域では近年の急速な経済発展に伴い血清総コレステロール値や肥満度の上昇も報告されており，高コレステロール血症やメタボリックシンドローム(MetS)の増加も懸念されている．これらはすべて冠動脈性心疾患の危険因子であるため，喫煙単独のリスクだけでなく，これら代謝性因子との合併リスクや個々の危険因子の頻度などを踏まえて予防対策を考えていく必要がある．我が国もその例外ではなく，日本国民を対象とした疫学研究で喫煙や喫煙と他の危険因子が合併した場合のリスクを検証しておく必要がある．

本稿では，最近の国内のコホート研究の知見を中心に述べてみる．

1．喫煙と循環器疾患の関連

表1に1990年以降の我が国の喫煙と冠動脈性心疾患，心血管病の発症および死亡に関する前向きコホート研究をまとめた．我が国の疫学研究では1990年代に久山町研究で男女ともに喫煙は冠動脈性心疾患発症の危険因子であることが示された[1]．そして2000年以降，大規模な前向きコホート研究であるNIPPON DATA80やJACC study，JPHC studyにより，1日の喫煙本数が多い者では冠動脈性心疾患の死亡リスクはより上昇すること[2,3]，喫煙者は非喫煙者に比べて多変量調整しても冠動脈性心疾患の発症リスクが約3倍上昇すること[4]，冠動脈性心疾患死亡の相対リスクは男性より女性で高いこと[3]などが示された．

また近年，吹田研究やNIPPON DATA90で，喫煙とMetSの合併リスクについて検討が行われている．吹田研究の男性の心血管病(心筋梗塞と脳卒中)発症の相対危険度は，非喫煙かつMetSなしを1とすると，喫煙のみで2.1倍，MetSのみでも2.1倍，両方を有すると3.6倍であった．これは女性では2.7倍，2.3倍，4.8倍であった(年齢，飲酒，腎機能，non-HDLコレステロールを調整，MetSはmodified NCEP-ATP IIIの基準で定義)[5]．一方，NIPPON DATA90では同じMetSの基準を用いて心血管病死亡をエンドポイントとした相対危険度を算出し，男性では喫煙のみで3.5倍，喫煙+MetSで3.2倍，女性では喫煙のみで3.6倍，喫煙+MetSで4.9倍であった[5]．

これらのコホート研究は実施された場所も時代も異なり，またエンドポイントも異なってい

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表1　喫煙と冠動脈性心疾患，心血管病の発症および

	著者	雑誌名(年；巻)	対象者数	追跡年数
久山町研究[1]	藤島ら	Clin Exp Hypertens A(1992: 14)	1,603(第一集団) 2,048(第二集団)	26(第一集団) 13(第二集団)
NIPPON DATA80[2]	上島ら	Stroke(2004; 35)	9,638	14
JACC study[3]	磯ら	Am J Epidemiol(2005: 161)	94,683	10
JPHC study[4]	馬場ら	Eur J Cardiovasc Prev Rehabil (2006; 13)	41,282	11
吹田研究[5]	東山ら	Circ J(2009: 73)	3,911	11.9
NIPPON DATA90[6]	高嶋ら	BMC Public Health(2010; 10)	6,650	15

NIPPON DATA: National Integrated Project for Prospective Observation of Non-communicable Disease
JACC study: Japan Collaborative Cohort study, JPHC study : Japan Public Health Center-based prospec-

るが全体の傾向はほぼ同じである．これらをまとめると，我が国における喫煙による冠動脈性心疾患や心血管病リスクの上昇は2-4倍であり，相対危険度は男性よりもむしろ女性で高いこと，また喫煙とMetSが併存すると単独の場合よりもリスクが増強されるという結果であった．

2. 喫煙，血清総コレステロールと冠動脈性心疾患の関連

前述のように我が国の疫学研究でも喫煙は心血管病の明らかな危険因子であることが示されているが，1990年以前の疫学研究でははっきりした関連を認めていなかった．日本人の移民研究であるNIHON SAN研究では，喫煙の冠動脈性心疾患死亡に対するリスクがハワイ在住日系人では高いにもかかわらず，日本在住日本人では明確ではなかった[7]．そのため喫煙と総コレステロールの冠動脈性心疾患への影響には交互作用があり，喫煙のリスクはコレステロールレベルが高くなるほど増強されるのではないかという仮説が提唱された[2]．NIPPON DATA80の19年追跡では，喫煙による虚血性の心血管病(冠動脈性心疾患＋非出血性脳卒中)のリスクは(非喫煙者を1とする)，血清総コレステロール(TC)低値群(165mg/dL未満)で男性1.07，女性1.86なのに対し，TC高値群(209mg/dL以上)では男性2.60，女性4.24であり，この仮説が支持された[8]．

アジア太平洋地域の34のコホート研究を個人データベースで統合して解析を行っているAsia Pacific Cohort Studies Collaboration(APCSC)でもこの仮説の検証が行われている．約250万人・年，冠動脈性心疾患3,298例(1,044例はアジア地域で残りはオーストラリアとニュージーランド)，脳卒中4,318例(同じくアジア地域が2,976例)という巨大なデータセットが用いられた[9]．その結果を**図1**に示す．ここではNIPPON DATAとは逆にTC(とHDLコレステロール，HDLC)の冠動脈性心疾患に対するリスクを喫煙者と非喫煙者で比較している．**図1-a**のTCの結果をみると，TCの上昇に伴う冠動脈性心疾患リスクの上昇が喫煙者の方でより急峻なことがわかる．またHDLCの低値に伴うリスク上昇も喫煙者の方が大きい．TCの一標準偏差(1.06mmol/L)上昇あたりの冠動脈性心

死亡に関する日本の前向きコホート研究

エンドポイント	主要な結果
冠動脈性心疾患発症	喫煙者は非喫煙者に比べて冠動脈性心疾患の発症率が高かった．男女ともに，喫煙は冠動脈性心疾患発症の危険因子であることが示された．
全心疾患死亡 冠動脈性心疾患死亡	男性では，1日の喫煙本数が21本以上の喫煙者は非喫煙者に比べて冠動脈性心疾患の死亡リスクは約4倍，全心疾患の死亡リスクは約2倍高かった．女性では，有意な関連は認められなかった．
冠動脈性心疾患死亡	喫煙者は非喫煙者に比べて冠動脈性心疾患の死亡リスクが男性で約2.5倍，女性で約3.5倍高かった．1日の喫煙本数が20本以上の喫煙者だと，非喫煙者に比べて同死亡リスクが男性で約3倍，女性で約6倍高かった．
冠動脈性心疾患発症 心筋梗塞発症	男女ともに，喫煙者は非喫煙者に比べて冠動脈性心疾患の発症リスクは約3倍，心筋梗塞の発症リスクは約3-4倍高かった．
循環器疾患発症 心筋梗塞発症	男女ともに，喫煙とメタボリックシンドロームの2つの危険因子をあわせもつと循環器疾患発症のリスクは高くなった(男性3.6倍，女性4.8倍)．男性では，喫煙の循環器疾患発症への人口寄与危険割合はメタボリックシンドローム単独より高い．
循環器疾患死亡	男女ともに，喫煙とメタボリックシンドロームの2つの危険因子をあわせもつと循環器疾患死亡のリスクは高くなった(男性3.2倍，女性4.9倍)．男女とも，喫煙の循環器疾患死亡への人口寄与危険割合はメタボリックシンドローム単独より高い．

And its Trends in the Aged.
tive study.

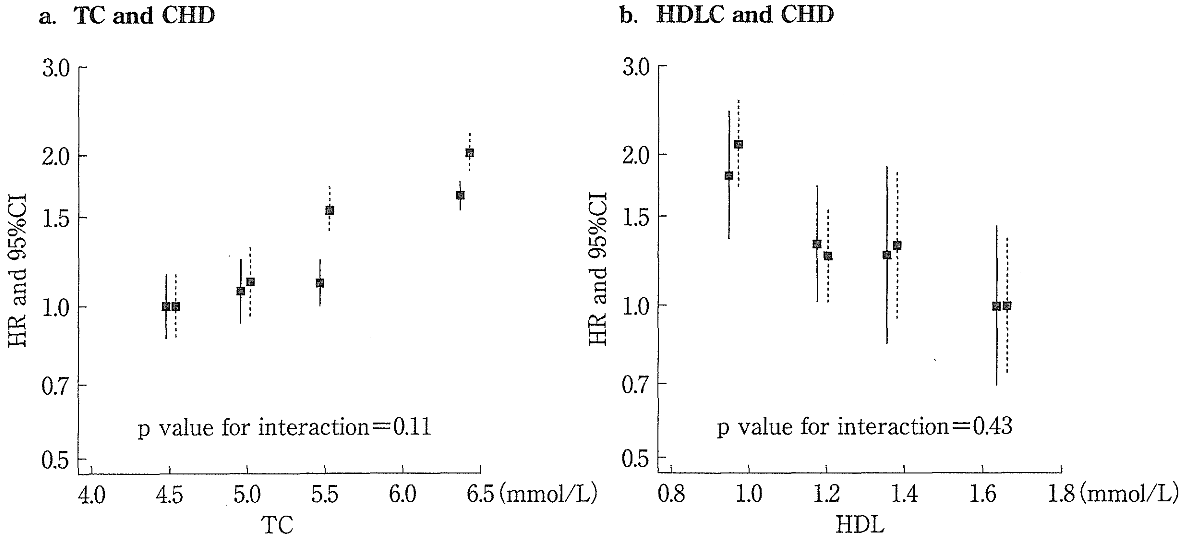

図1　喫煙状況別にみた血清総コレステロールと冠動脈性心疾患の関連(文献[9]より引用)

TC: 血清総コレステロール，CHD: 冠動脈性心疾患，HDLC: HDLコレステロール．HR: ハザード比，interaction: 交互作用．

コレステロール1mmol/Lは38.7mg/dL．信頼区間の線が実線の場合は非喫煙者，点線の場合は喫煙者．

疾患相対リスクの上昇(ハザード比，HR)は，非喫煙者で1.38，喫煙者で1.54であり，連続量の交互作用は有意であった(p=0.02)．同様にHDLCの一標準偏差(0.40mmol/L)減少あたりの冠動脈性心疾患リスクの上昇は，非喫煙者で1.28，喫煙者で1.67であり，こちらも交互作用は有意であった(p=0.04)．

この理由としてTC(LDLコレステロール)は，小児の動脈に既にfatty streakがあるなど比較的若年期から動脈硬化の危険因子として作用し，

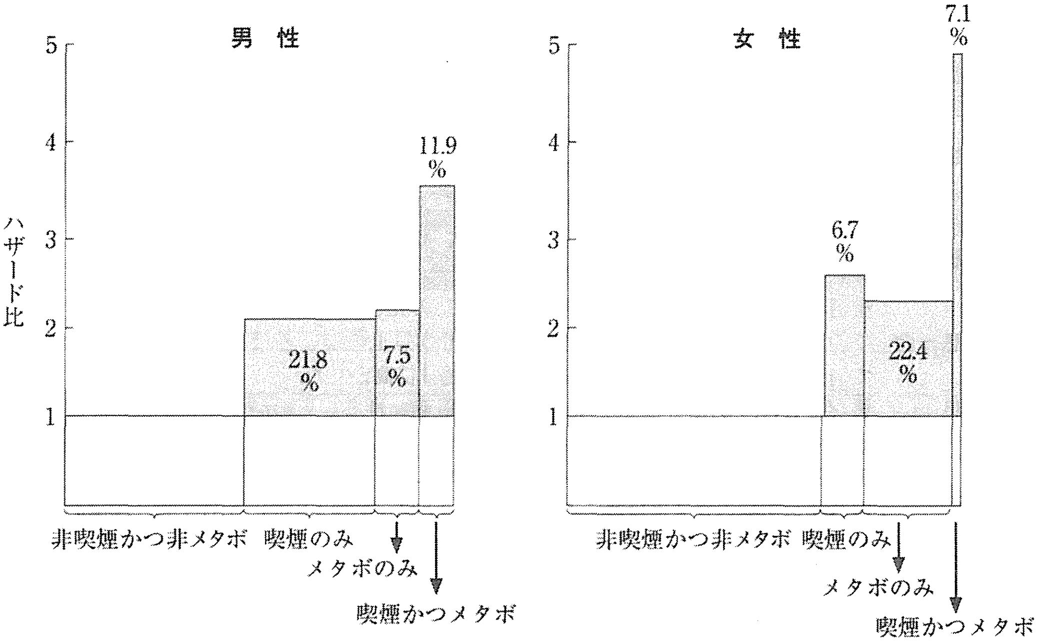

図2　喫煙とメタボリックシンドロームの心血管病に対する人口寄与危険割合：吹田研究
(文献[5]より引用)

喫煙は成人期以降の動脈硬化の危険因子であることが考えられる．両者は異なる機序と時間軸で冠動脈性心疾患のリスクになっており，その結果，相乗的に作用している可能性が考えられた．吹田研究などで示されたMetSや喫煙と心血管病の関連にも同じことがいえるかもしれない[5,6]．このように喫煙と代謝性の危険因子を複合してもっている者に対しては，まず禁煙させることにより大きなリスク減少が期待されるため禁煙指導が非常に重要となる．

3. 喫煙の集団全体の心血管病発症数への影響

ある曝露要因が集団内のある疾患の患者数をどれだけ増やしているかは，人口寄与危険割合(population attributable fraction: PAF)という指標で計算できる．PAFには幾つかの計算手法があるが，基本的には曝露要因の影響の強さ(相対危険度やHRで示される)と曝露要因の集団内での頻度で決定される．日本人男性の喫煙率は欧米諸国より高いため，喫煙の疾病に対するPAFは大きくなりやすい．わかりやすくするためにMetSと喫煙のPAFを比べてみた．

図2は前述した吹田研究におけるMetSと喫煙のPAFであり[5]，棒グラフの高さは相対危険度を，グラフの面積は曝露要因を有する心血管病患者の数を示している．男性のPAFは喫煙のみ群で21.8％，MetSのみ群で7.5％であり，喫煙で発症した心血管病はMetSの約3倍多いことがわかる．一方，女性では喫煙のPAFは小さくMetSのPAFが大きい．これは女性の喫煙率が低いためであるが，この研究のMetSはmodified NCE基準で定義されている．これをもしMetSの日本基準に置き換えると，ウエスト90 cm以上が必須項目になっているため女性のMetSの頻度が激減し，心血管病に対するPAFは喫煙のみ群で8.1％，MetSのみ群で5.2％，両方有する群で1.8％となった(岡村智教ほか．平成22年度厚生労働科学研究‘各種禁煙対策の経済影響に関する研究—医療費分析と費用対効果分析—’分担研究報告より)．NIPPON DATA90の心血管病死亡に対する喫煙のみ群のPAFは，男性で35.6％，女性で7.2％であり，やはり男性で大きな割合を示した．男性の場合，MetS対策も重要であるが，まず喫煙率を下げることが心血管病患者を減らすために有効な手

段と考えられた.

おわりに

従来から心血管病の予防というとMetSや高コレステロール血症などの代謝性の因子や高血圧などに目が向きがちであり, 現在もその傾向はあまり変わっていない. また, 喫煙対策というとがん予防という意識がいまだ国民感情としても強い. しかし, 日本人男性の喫煙率は先進国中で最も高いレベルにあり, すぐ実行可能な心血管病の予防対策として禁煙の推進は非常に重要である. 日常診療や健診などの場で喫煙者への啓発が必要である.

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Short Communication

Perceptions and Practices of Japanese Nurses Regarding Tobacco Intervention for Cancer Patients

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ABSTRACT

Background: We investigated the perceptions and practices regarding tobacco intervention among nurses, as improvement of such practices is important for the management of patients who smoke.

Methods: Self-administered questionnaires were delivered by hospital administrative sections for nursing staff to 2676 nurses who were working in 3 cancer hospitals and 3 general hospitals. Of these, 2215 (82.8%) responded.

Results: Most nurses strongly agreed that cancer patients who had preoperative or early-clinical-stage cancer but continued to smoke should be offered a tobacco use intervention. In contrast, they felt less need to provide tobacco use intervention to patients with incurable cancer who smoked. Most nurses felt that although they assessed and documented the tobacco status of cancer patients, they were not successful in providing cessation advice, assessing patient readiness to quit, and providing individualized information on the harmful effects of tobacco use. In multivariate analysis, nurses who received instruction on smoking cessation programs during nursing school were more likely to give cessation advice (odds ratio, 1.61; 95% confidence interval, 1.15–2.26), assess readiness to quit (1.73, 1.09–2.75), and offer individualized explanations of the harmful effects of tobacco (1.94, 1.39–2.69), as compared with nurses who had not received such instruction.

Conclusions: The perceptions of Japanese nurses regarding tobacco intervention for cancer patients differed greatly by patient treatment status and prognosis. The findings highlight the importance of offering appropriate instruction on smoking cessation to students in nursing schools in Japan.

Key words: smoking cessation; intervention; nurses; perception

INTRODUCTION

Smoking cessation reduces the risk of developing tobacco-related cancer.[1] In addition, preoperative abstinence from cigarette smoking can reduce pulmonary and wound-related complications among patients with cancer[2–4] and patients undergoing orthopedic surgery.[5] Smoking cessation also prevents recurrence in patients with a potentially curable tobacco-related cancer,[6,7] reduces the risk of developing a secondary tobacco-related cancer,[8,9] decreases the risk of treatment side effects,[10] and improves cancer survival.[11] These findings demonstrate the importance of tobacco intervention practices for cancer patients who smoke.

During screening, diagnosis, treatment, rehabilitation, and supportive care, nurses have many opportunities to intervene with smokers and recent quitters at risk for relapse, and evidence shows that nurses can provide effective tobacco cessation interventions.[12,13] However, attitudes toward such interventions might differ according to the characteristics of nurses and patient health status. Little is known about the perceptions and practices of nurses regarding tobacco intervention for cancer patients in Japan. Thus, we administered a questionnaire survey to examine the perceptions and practices of Japanese nurses working in cancer hospitals and general hospitals regarding tobacco intervention for cancer patients.

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METHODS

Study subjects

We selected 6 hospitals from among cancer hospitals and general hospitals in Japan. Three are classified as designated cancer hospitals by the Japanese Ministry of Health, Labour and Welfare, ie, they have more than 399 beds and more than 84% of inpatients are cancer inpatients (National Cancer Center Central Hospital, Tokyo; Aichi Cancer Center Central Hospital, Aichi; Kyusyu Cancer Center Hospital, Fukuoka). The other 3 are general hospitals with more than 649 beds and in which 20% to 35% of inpatients are cancer inpatients (Iwate Prefectural Hospital, Iwate; Nagoya Medical Center Hospital, Aichi; Osaka Medical Center Hospital, Osaka). There were 2782 nurses working at the 6 selected hospitals in April 2008. We excluded nurses who were absent for 1 month or longer (eg, due to pregnancy or illness), and the remaining 2676 nurses were eligible to participate.

Questionnaire survey

We mailed a self-administered questionnaire to the administrative section for nursing staff in each of the 6 hospitals. The administrative section then delivered the questionnaire with a cover letter and a return envelope to the study subjects and asked that they return it anonymously to the administrative section within 2 weeks. The cover letter explained to the nurses that their participation in this study was completely voluntary. To maintain subject autonomy, we did not send reminder letters. This study was approved by the Institutional Review Board of Nagoya Medical Center.

Questionnaire items

The questionnaire items comprised subject demographics, perceptions toward tobacco use interventions, and recent 3-year practice in tobacco use interventions. The nurses were asked about their perceptions toward tobacco use interventions for 5 categories of hypothetical cancer patients, which were based on patient physical condition, treatment modality, and/or prognosis: (a) preoperative patients, (b) postoperative patients with early-clinical-stage cancer, (c) postoperative patients who received chemoradiotherapy and have an expected survival period of approximately 3 years, (d) postoperative patients who have clinically advanced cancer but are now free from symptoms and have an expected survival time of 1 year, and (e) patients with a terminal prognosis receiving palliative care. In each of the 5 categories, we established 2 subcategories (5 × 2) according to the type of cancer: tobacco-related cancers (head and neck, esophagus, and lung) and other cancers. For the 10 categories of patients, the nurses' perception of the importance of tobacco intervention was assessed using 5 response categories, ranging from "strongly agree" to "strongly disagree".

The nurses were asked about the frequency of their involvement in tobacco assessment and interventions in practice using a 4-point scale ranging from "almost always" to "never or rarely". The questionnaire items included were: (a) assessed and documented tobacco use, (b) provided cessation advice, (c) assessed readiness to quit, (d) provided individualized information about the harmful effects of tobacco use, and (e) made arrangements for enrollment in a smoking cessation program.

The questionnaire included the respondent's demographic, professional, and institutional characteristics, and his/her own smoking status. We also asked whether they had received instruction on smoking cessation programs in nursing school.

Assessment and statistical methods

The summary statistics of perceptions toward tobacco use interventions indicate the proportion of those who indicated that they strongly agreed with a questionnaire item, as we felt that this proportion best reflected the distribution of perception in the 5-part response categories (Figure A1). The summary statistics of tobacco assessment and interventions were calculated using the proportion of those who responded "almost always" to each questionnaire item. The chi-square test was used to compare summary statistics between strata. To elucidate factors associated with perceptions and practices of tobacco use assessment or interventions for cancer patients who smoke, we performed multivariate logistic regression analysis using the following independent variables: age 20 to 29 (yes/no), working in inpatient care (yes/no), working in a surgical division (yes/no), received any academic certification (yes/no), working in a designated cancer hospital (yes/no), and received instruction on smoking cessation programs during nursing school (yes/no). All analyses were performed using STATA version 10 (STATA Corp, College Station, TX, USA).

RESULTS

The response rates at the 6 hospitals were as follows. Designated cancer hospitals—National Cancer Center Central Hospital (Tokyo), 85% (397/468); Aichi Cancer Center Central Hospital (Aichi), 84% (288/342); Kyusyu Cancer Center (Fukuoka), 89% (233/261). General hospitals—Iwate Prefectural Hospital (Iwate), 76% (392/517); Nagoya Medical Center Hospital (Aichi), 86% (431/499); and Osaka Medical Center Hospital (Osaka), 80% (474/589).

Table 1 shows the characteristics of the 2115 respondents: 41% of respondents worked at a designated cancer hospital, 96% were female, and just over half (51%) were aged 20 to 29 years. Seventy-three percent had received a 3-year nursing degree, 45% had worked for less than 6 years as a nurse, 74% were currently working in an inpatient care setting, and 83% were staff nurses. Only 8% reported current smoking; 12% were former smokers.

The nurses' perceptions toward tobacco use intervention varied widely with regard to the physical condition and

Table 1. Characteristics of the study subjects (*n* = 2215)

Characteristic	*n*	%
Designated cancer hospital	918	41
General hospital	1297	59
Female	2128	96
Age, years		
20–29	1137	51
30–39	699	32
40+	376	17
Length of nursing education, years		
2	184	8
3	1628	73
4	348	16
Master's degree	15	<1
Length of employment as a nurse, years		
<3	581	26
3–5	418	19
6–9	378	17
10–15	409	18
≥16	426	19
Current work setting		
Inpatient care	1642	74
Outpatient care	204	9
Operating room/intensive care unit	295	13
Other	65	3
Primary position		
Staff nurse	1834	83
Head nurse	229	10
Supervising nurse	93	4
Assistant director/director	10	<1
Certified by Japan Nursing Association	51	2
Certified by other academic society	30	1
Smoking status		
Current smoker	170	8
Ex-smoker	275	12
Never smoker	1731	78

prognosis of the cancer patients (Figure 1). Most nurses strongly agreed that tobacco use intervention should be provided to currently smoking cancer patients who were in a preoperative stage or had early-clinical-stage cancer. In contrast, they felt less need to provide intervention to incurable cancer patients who smoke. The subjects felt that the need for tobacco use intervention was significantly higher in patients with tobacco-related cancers than in those with non-tobacco-related cancers in all 5 categories ($P < 0.01$).

The proportions of responses in each of the 5 categories of tobacco intervention perception are shown in Supplemental Figure A1. The proportion of nurses who strongly agreed or agreed with the need for tobacco use intervention declined with deteriorating patient health. In multivariate analysis, the nurses working in designated cancer hospitals had a significantly more positive perception of tobacco intervention for preoperative cancer patients than did nurses working in general hospitals (odds ratio [OR] 2.67, 95% confidence interval [CI] 1.60–4.45 for patients with tobacco-related cancers; OR 1.79, 95% CI 1.43–2.25 for patients with non-tobacco-related cancers). In contrast, nurses working in designated cancer hospitals had a significantly more negative perception of tobacco intervention for patients with a terminal prognosis receiving palliative care (OR 0.66, 95% CI 0.51–0.84 for patients with tobacco-related cancers; OR 0.57, 95% CI 0.40–0.81 for patients with non-tobacco-related cancers).

The frequency of involvement in tobacco assessment and intervention varied widely, as shown in Figure 2: 62% of nurses responded that they "almost always" assessed and documented tobacco use, whereas only 10% indicated that they "almost always" assessed readiness to quit in cancer

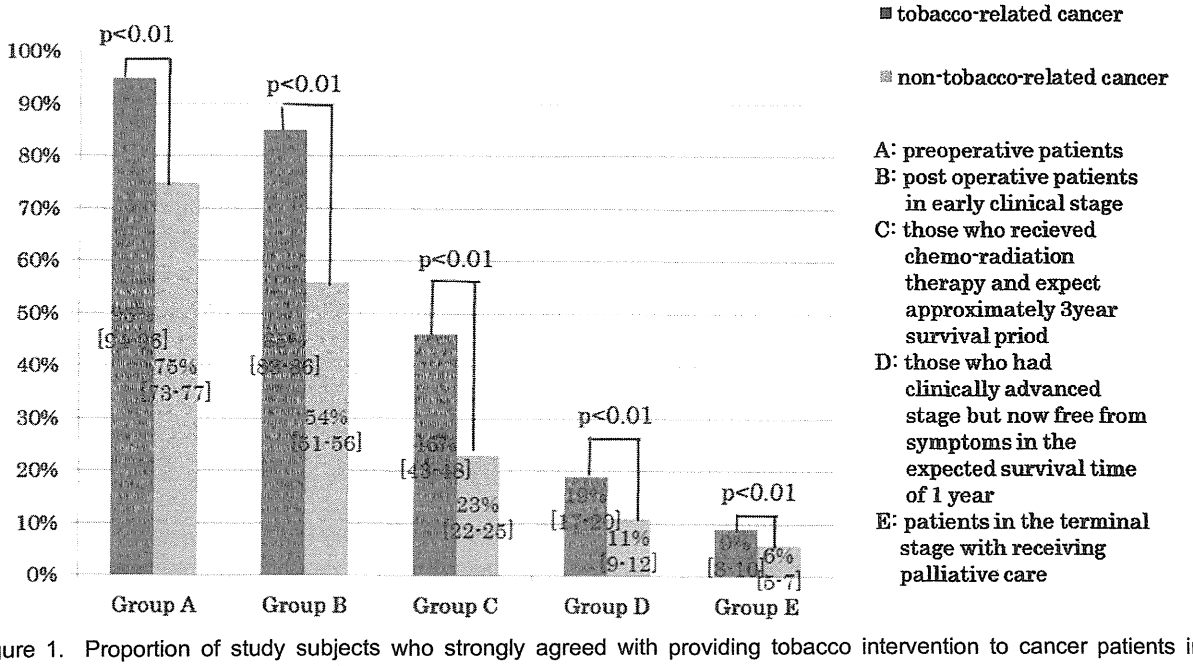

Figure 1. Proportion of study subjects who strongly agreed with providing tobacco intervention to cancer patients in various states of health (A–E).

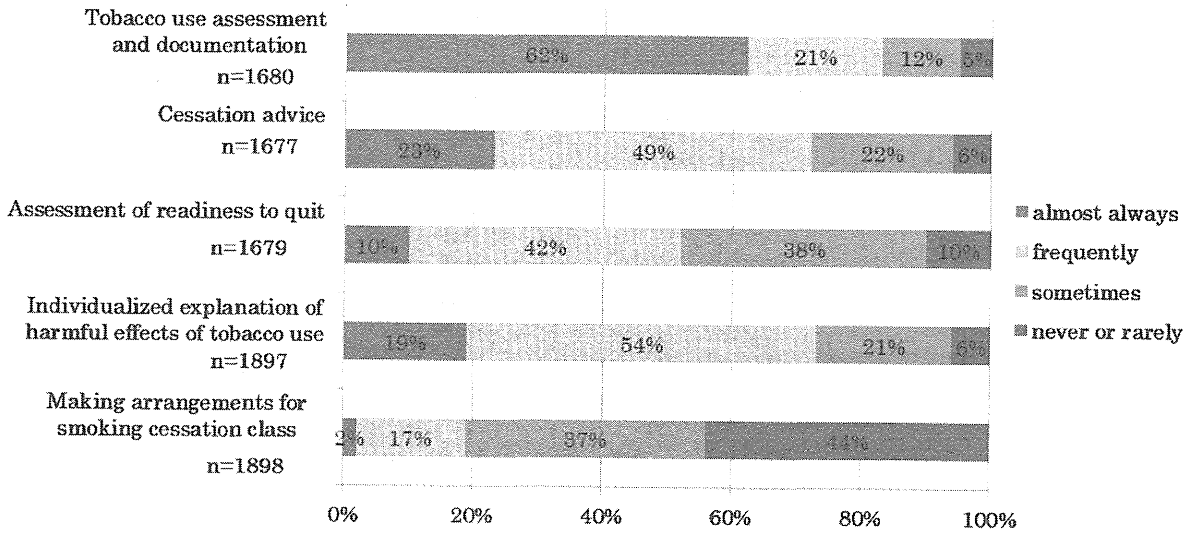

Figure 2. Frequency of performing tobacco use assessment and intervention during a recent 3-year period for currently smoking patients with cancer.

patients. Cessation advice to cancer patients who smoke was "almost always" or "frequently" provided by 72% of the respondents, whereas only 19% of them made arrangements for enrolling patients in a smoking cessation program (Figure 2).

The frequency of tobacco use assessment and documentation significantly differed according to respondent age, length of nursing education, current work setting (inpatient care/other), nursing certification status, and type of hospital (cancer hospital/general hospital) (Table 2). Current work setting (surgical division/other), type of hospital, and history of receiving instruction on smoking cessation programs in nursing school were significantly associated with the frequency of providing cessation advice. Assessment of readiness to quit and providing individualized explanation of the harmful effects of tobacco use were significantly associated with the nurses' current work setting, certification status, type of hospital, and history of receiving instruction in smoking cessation programs. There was no significant difference in the frequency of tobacco assessment or intervention with regard to respondent smoking status (Table 2).

In multivariate analysis, the current work setting of inpatient care was significantly associated with performing tobacco use assessments and documentation (OR 1.57, 95% CI 1.14–2.16; Table 3). Current work in a surgical setting was significantly associated with providing cessation advice (OR 1.83, 95% CI 1.40–2.39) and providing individualized explanation of the harmful effects of tobacco use (OR 1.58, 95% CI 1.21–2.05). Nurses with an academic certification were significantly more likely to assess readiness to quit than those without such certification (OR 2.33, 95% CI 1.29–4.21). All 4 tobacco intervention practices were significantly more frequent among nurses working in a designated cancer hospital than among those in general hospitals. Nurses who received instruction on smoking cessation programs in their nursing school were significantly more likely to provide cessation advice (OR 1.61, 95% CI 1.15–2.26), assessment of readiness to quit (OR 1.73, 95% CI 1.09–2.75), and individualized explanation of the harmful effects of tobacco use (OR 1.94, 95% CI 1.39–2.69).

DISCUSSION

To our knowledge, there have been no Asian studies of nurses' perceptions of tobacco intervention for cancer patients who smoke, although the attitudes of people with cancer regarding smoking cessation and the patient education practices of oncology nurses in Japan, Taiwan, and Korea were reported in a small study.[14] Our study showed that nurses' perceptions toward tobacco intervention were highly dependent on the health and prognosis of cancer patients and whether their cancer was tobacco-related. The Japanese nurses showed less willingness to provide tobacco intervention for cancer patients with a poor prognosis. In particular, the nurses working in designated cancer hospitals had a significantly more negative perception of tobacco intervention for patients with a terminal prognosis who were receiving palliative care, possibly because they believed that these patients would derive limited benefit from smoking cessation. However, we believe that this attitude is not appropriate because continued smoking reduces treatment effectiveness and results in faster deterioration of health, even in patients with incurable cancer. The present study also showed that the Japanese nurses were less willing to provide tobacco intervention for patients with non-tobacco-related cancers than for those with tobacco-related cancers. This was probably due to the nurses' incorrect belief that currently smoking patients with non-tobacco-related cancers do not believe that smoking cessation would

Table 2. Proportions of nurses who, during their most recent 3 years of practice, almost always performed tobacco use assessments or interventions for currently smoking cancer patients, by characteristics of nurses

Nurse characteristic	Tobacco use assessment and documentation				Cessation advice			Assessment of readiness to quit			Individualized explanation of harmful effects of tobacco use		
	n	%	95% CI	*P* value	%	95% CI	*P* value	%	95% CI	*P* value	%	95% CI	*P* value
Age 20–29													
Yes	1137	65	61.4–67.8	**0.01**	24	20.8–26.4	0.69	9	7.0–10.7	0.14	19	16.1–20.9	0.19
No	1075	59	55.1–62.0		23	19.9–25.7		11	8.8–13.1		26	18.2–23.5	
Length of nursing education													
≥4 years	363	70	64.6–75.5	**<0.01**	24	19.3–29.5	0.61	10	7.5–15.0	0.37	20	15.8–24.9	0.71
<4 years	1845	60	57.5–62.6		23	20.7–25.2		11	8.0–11.0		19	17.5–21.4	
Current work setting													
Inpatient care	1642	64	61.1–66.3	**<0.01**	24	21.8–26.5	0.12	9	7.9–11.1	0.28	20	17.7–21.7	0.99
Other	564	55	49.8–60.2		20	16.0–24.5		11	8.1–14.7		20	15.8–23.6	
Current work setting													
Surgical division	883	63	58.9–67.7	0.5	28	24.9–33.2	**<0.01**	11	7.2–12.6	0.48	24	20.3–27.6	**<0.01**
Other	1335	61	57.9–63.8		21	18.5–23.4		10	7.9–11.5		18	15.4–19.8	
Any academic certification													
Yes	126	52	41.3–61.8	**0.04**	31	21.1–40.0	0.08	20	11.8–28.2	**<0.01**	29	20.0–37.4	**0.01**
No	2074	62	60.0–64.8		23	20.7–24.9		9	8.9–10.8		19	17.1–20.8	
Workplace													
Designated cancer hospital	918	73	69.9–76.4	**<0.01**	35	31.7–38.8	**<0.01**	15	12.3–17.6	**<0.01**	28	24.8–31.1	**<0.01**
General hospital	1297	53	50.1–56.4		14	12.1–16.6		6	4.6–7.6		14	11.7–15.7	
Received instruction[a]													
Yes	346	68	62.0–73.8	0.05	31	25.7–37.4	**<0.01**	13	9.6–18.3	**0.04**	27	22.2–32.6	**<0.01**
No	1838	61	58.6–63.6		22	19.7–23.9		9	7.6–10.6		18	16.2–19.9	
Attended lecture[b]													
Yes	210	69	61.3–76.6	0.05	23	16.0–29.9	0.92	14	8.1–19.6	0.12	25	18.8–32.1	0.06
No	1965	61	59.0–63.9		23	21.3–25.6		10	8.1–11.1		19	17.0–20.7	
Smoking status													
Never	1731	62	59.3–64.6	0.62	23	20.8–25.3	0.6	10	8.2–11.5	0.65	19	17.3–21.3	0.58
Current or ex-smoker	445	61	55.4–65.7		24	19.6–28.6		9	6.1–12.2		20	16.3–24.3	

[a]Received instruction on smoking cessation programs at his/her nursing school.
[b]Attended a lecture on smoking cessation intervention at his/her hospital.
95% CI: 95% confidence interval.

Table 3. Factors associated with almost always performing tobacco use assessment and interventions for currently smoking cancer patients during the most recent 3 years of practice in Japanese nurses (multivariate logistic regression)

	Tobacco use assessment and documentation			Cessation advice			Assessment of readiness to quit			Individualized explanation of harmful effects of tobacco use		
	OR	(95% CI)	*P* value	OR	(95% CI)	*P* value	OR	(95% CI)	*P* value	OR	(95% CI)	*P* value
Age 20–29 years	1.13	(0.89–1.42)	0.31	0.98	(0.75–1.29)	0.9	0.71	(0.48–1.04)	0.08	0.78	(0.60–1.03)	0.08
Inpatient care	1.57	(1.14–2.16)	0.006	1.41	(0.94–2.11)	0.1	0.93	(0.56–1.54)	0.78	1.02	(0.70–1.50)	0.9
Surgical division	1.21	(0.96–1.53)	0.11	1.83	(1.40–2.39)	0.000	1.02	(0.70–1.51)	0.89	1.58	(1.21–2.05)	0.001
Any academic certification	0.69	(0.43–1.11)	0.13	1.57	(0.92–2.67)	0.1	2.33	(1.29–4.21)	0.005	1.63	(0.99–2.69)	0.06
Designated cancer hospital	2.36	(1.88–2.95)	0.000	3.49	(2.70–4.51)	0.000	2.71	(1.89–3.88)	0.000	2.58	(2.00–3.32)	0.000
Received instruction[a]	1.18	(0.86–1.62)	0.3	1.61	(1.15–2.26)	0.006	1.73	(1.09–2.75)	0.02	1.94	(1.39–2.69)	0.000

[a]Received instruction on smoking cessation programs at his/her nursing school.
OR: odds ratio, 95% CI: 95% confidence interval.

improve their health and/or they are less motivated than those with tobacco-related cancers to stop smoking. Therefore, we believe that modifying nursing education might change the incorrect attitudes of nurses toward tobacco intervention for cancer patients in Japan.

Regarding tobacco intervention practice, although most nurses assessed and documented the tobacco status of their patients, they did not often provide cessation advice, assess readiness to quit, provide individualized information about the harmful effects of tobacco use, or make

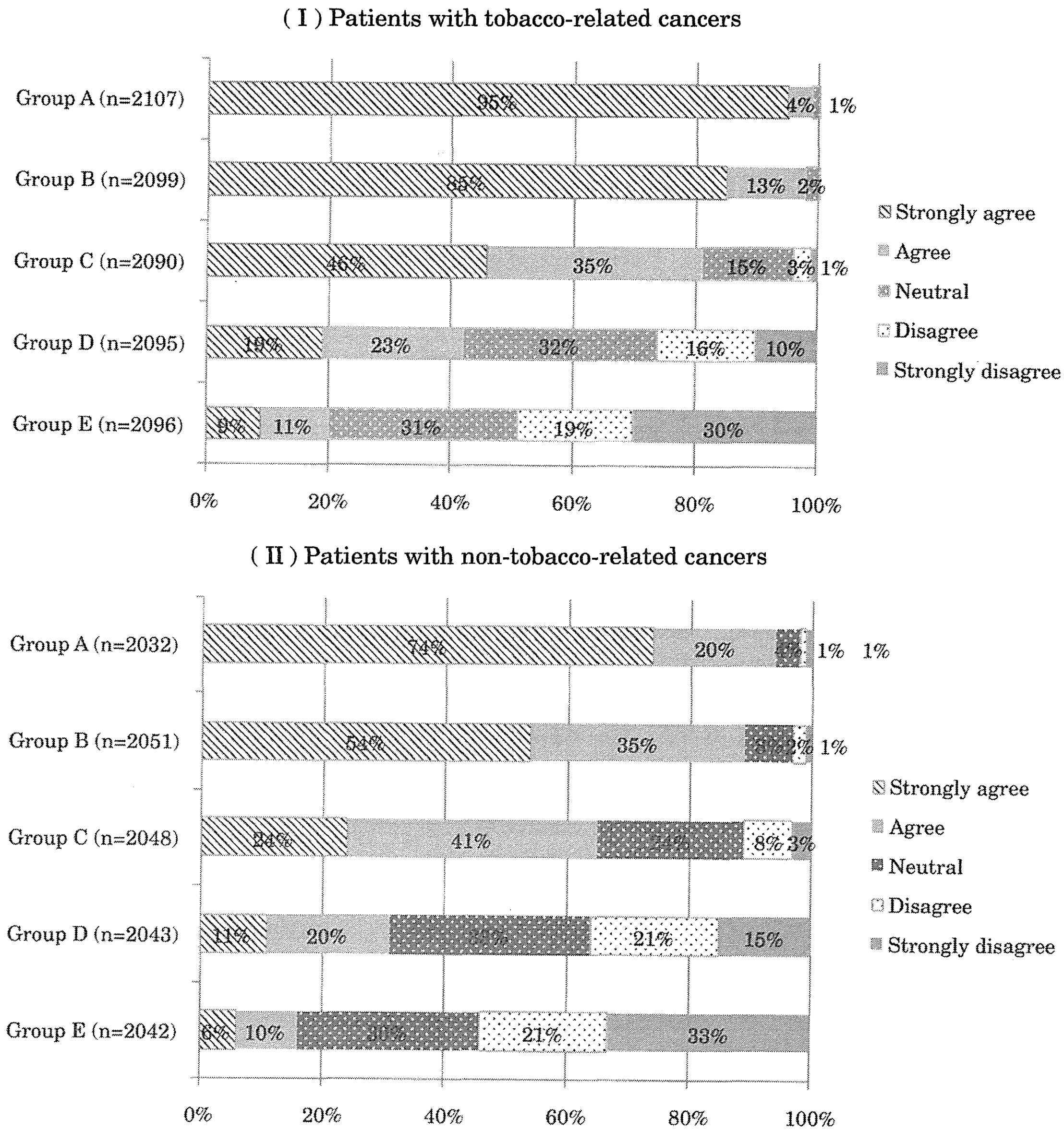

Figure A1. Responses of nurses regarding the need for tobacco intervention in cancer patients, by cancer type and state of health. Group A: Preoperative patients. Group B: Postoperative patients with early-clinical-stage cancer. Group C: Patients who received chemoradiotherapy and have an expected survival time of approximately 3 years. Group D: Postoperative patients who have clinically advanced cancer but are now free from symptoms and have an expected survival time of 1 year. Group E: Patients with a terminal prognosis receiving palliative care.

arrangements for patients to enroll in a smoking cessation program. Except for assessing and documenting tobacco status, the frequencies of these practices in the present study were lower than those among oncology nurses in the United States assessed in 1998, as indicated by the proportions of nurses reporting a frequency of "every day" or "every week" (provided cessation advice: 23% vs 32%; assessed readiness to quit: 10% vs 38%). However, it should be noted that the response rate in the US survey was only 38%.[15] The low frequency of making arrangements for cancer patients to enroll in a smoking cessation program in the present study was possibly influenced by the considerable number of patients with limited readiness to quit and low activities of daily living, as well as the limited availability of smoking cessation programs in patients' areas of residence.

From the perspective of nurses' behavior regarding tobacco intervention for cancer patients who smoke, an important finding was that these behaviors were positively associated with a history of instruction in smoking cessation programs during nursing school, after adjustment for a number of confounding factors. This finding confirmed the importance of providing instruction on smoking cessation in the standard curriculum of nursing schools in Japan.

One limitation of our study was the representativeness of the sample we obtained. We selected nurses working at 3 designated cancer hospitals and 3 general hospitals. Although their baseline characteristics were well documented, the findings may not be applicable to nurses working in smaller hospitals, as their characteristics might differ from those of our respondents. Our multivariate analysis showed that nurses working in the designated cancer hospitals and those with any academic certification in nursing education or technique were more likely to provide smoking cessation interventions for cancer patients, which suggests that the frequency of smoking cessation intervention by nurses in the present study might be higher than that among Japanese nurses in general. To improve representativeness, we need to perform another survey of nurses stratified by specialty and hospital size. Our study did not assess the tobacco intervention perception and practices of nurses with regard to patients' readiness to quit and other behavior-related characteristics such as self-efficacy in quitting. To improve the usefulness of the assessment, we need to examine these items on patient smoking-related characteristics in a future study.

In conclusion, we observed that the perceptions of Japanese nurses toward tobacco intervention in cancer patients differed greatly with regard to patient treatment status and prognosis. In addition, the nurses' tobacco intervention practices were significantly associated with a history of instruction in smoking cessation programs while they were in nursing school. These findings should be useful in improving tobacco intervention attitudes and practices among nurses treating patients with cancer in Japan.

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Conflicts of interest: None declared.

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Impact of obesity, overweight and underweight on life expectancy and lifetime medical expenditures: the Ohsaki Cohort Study

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ABSTRACT

Objectives: People who are obese have higher demands for medical care than those of the normal weight people. However, in view of their shorter life expectancy, it is unclear whether obese people have higher lifetime medical expenditure. We examined the association between body mass index, life expectancy and lifetime medical expenditure.
Design: Prospective cohort study using individual data from the Ohsaki Cohort Study.
Setting: Miyagi Prefecture, northeastern Japan.
Participants: The 41 965 participants aged 40–79 years.
Primary and secondary outcome measures: The life expectancy and lifetime medical expenditure aged from 40 years.
Results: In spite of their shorter life expectancy, obese participants might require higher medical expenditure than normal weight participants. In men aged 40 years, multiadjusted life expectancy for those who were obese participants was 41.4 years (95% CI 38.28 to 44.70), which was 1.7 years non-significantly shorter than that for normal weight participants (p=0.3184). Multiadjusted lifetime medical expenditure for obese participants was £112 858.9 (94 954.1–131 840.9), being 14.7% non-significantly higher than that for normal weight participants (p=0.1141). In women aged 40 years, multiadjusted life expectancy for those who were obese participants was 49.2 years (46.14–52.59), which was 3.1 years non-significantly shorter than for normal weight participants (p=0.0724), and multiadjusted lifetime medical expenditure was £137 765.9 (123 672.9–152 970.2), being 21.6% significantly higher (p=0.0005).
Conclusions: According to the point estimate, lifetime medical expenditure might appear to be higher for obese participants, despite their short life expectancy. With weight control, more people would enjoy their longevity with lower demands for medical care.

ARTICLE SUMMARY

Article focus

- Obese people have higher needs and demands for medical care.
- Obesity is associated with an increased risk of mortality.
- In view of the decreased life expectancy in obese participants, it is unclear whether lifetime medical expenditure increases or decreases as a result.

Key messages

- In spite of their short life expectancy, obese men and women had approximately 14.7% and 21.6% higher lifetime medical expenditure in comparison with normal weight participants, respectively.
- With better weight control, more people would enjoy their longevity with lower needs and demands for medical care.

Strengths and limitations of this study

- This is the first study to have investigated the association between body mass index, life expectancy and lifetime medical expenditure calculated from individual medical expenditure and mortality data over a long period in a general population.
- There was a limit to the accurate estimation of life expectancy and lifetime medical expenditure for obese participants because the Japanese population has a low prevalence of body mass index≥30.0 kg/m^2.

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INTRODUCTION

Obesity is closely associated with an increased risk of cardiovascular disease, cancer, hypertension, diabetes mellitus and other medical problems. Previous studies have reported that obese and overweight people have higher needs and demands for medical care than normal weight people.[1–5] However, it is unclear whether obese people have higher lifetime medical expenditure than those of the normal weight people because the former have a comparatively shorter life expectancy.[6–10] Additionally, underweight people have a higher risk of mortality and thus also tend to have higher medical expenditure per month or per person, based on a 10-year follow-up.[1 4]

Although four previous studies have examined the association between obesity and lifetime medical expenditure,[10–13] the results were inconsistent. One study showed that obese people had lower lifetime medical expenditure than those of the normal weight people,[11] whereas the others indicated that obese people had higher lifetime medical expenditure.[10 12 13] In addition, two of the four studies estimated lifetime medical expenditure from excess risk of cause-specific mortality and mean medical expenditure for the index disease.[10 11] Only the other two studies calculated lifetime medical expenditure on the basis of individual medical expenditure and mortality.[12 13] However, one of those studies followed up the participants for only 2 years[12] and the other calculated lifetime medical expenditure for elderly participants aged 70 years or over.[13] Therefore, the association between body mass index (BMI) and lifetime medical expenditure remains to be fully clarified.

We therefore conducted a 13-year prospective observation of 41 965 Japanese adults aged 40–79 years living in the community, which accrued 392 860 person-years. We examined the association between BMI and lifetime medical expenditure, based on individual medical expenditure and life table analysis.[1 14–17] We collected data for survival and all medical care utilisation and costs, excluding home care services provided home health aides, nursing home care and preventive health services in participants of this cohort study.

MATERIALS AND METHODS

Study cohort

We used data from the Ohsaki National Health Insurance (NHI) Cohort Study.[1 14 16–18] In brief, we sent a self-administered questionnaire on various lifestyle habits between October and December 1994 to all NHI beneficiaries living in the catchment area of Ohsaki Public Health Center, Miyagi Prefecture, northeastern Japan. A survey was conducted of NHI beneficiaries aged 40–79 years. Among 54 996 eligible individuals, 52 029 (95%) responded.

We excluded 776 participants who had withdrawn from the NHI before 1 January 1995, when we started the prospective collection of NHI claim files. Thus, 51 253 participants formed the study cohort. The study protocol was approved by the Ethics Committee of Tohoku University School of Medicine. The participants who had returned the self-administered questionnaires and had signed them were considered to have consented to participate in this study.

For the current analysis, we also excluded participants who did not provide information about body weight and height (n=3543), were at both extremes of the BMI range: lower than the 0.05th percentile for BMI (below 14.41 for men; below 13.67 for women) or higher than the 99.95th percentile for BMI (above 58.46 for men; above 62.00 for women; n=48), those who died within the first year (n=454) or those who had a history of cancer (n=1533), myocardial infarction (n=1233), stroke (n=831) or kidney disease (n=1646). Thus, a total of 41 965 participants (20 066 men and 21 899 women) participated.

Body mass index

The self-administered questionnaire included questions on weight and height, and BMI was calculated as weight divided by the square of height (kilograms per square metre). We divided the participants into groups according to the following BMI categories: <18.5 (underweight), 18.5–24.9 (normal weight), 25.0–29.9 (overweight) and ≥30.0 kg/m^2 (obesity). These BMI categories correspond to the cut-off points proposed by the WHO: normal BMI range (18.5–24.9 kg/m^2), grade 1 overweight (25.0–29.9 kg/m^2), grade 2 overweight (30.0–39.9 kg/m^2) and grade 3 overweight (≥40.0 kg/m^2).[19]

The validity of self-reported body weight and height has been reported earlier.[1] Briefly, the weight and height of 14 883 participants, who were a subsample of the cohort, were measured during basic health examinations provided by local governments in 1995. The Pearson correlation coefficient (r) and weighted κ (κ) between the self-reported values and measured values were r=0.96 (p<0.01) for weight, r=0.93 (p<0.01) for height and r=0.88 (p<0.01) and κ=0.72 for BMI categories.

Health insurance system in Japan

The details of the NHI system have been described previously.[1 4 14 16 18] Briefly, everyone living in Japan is required to enrol in one health insurance system. The NHI covers 35% of the Japanese population for almost all medical treatment, including diagnostic tests, medication, surgery, supplies and materials, physicians and other personnel costs and most dental treatment. It also covers home care services provided by physicians and nurses but not those by other professionals such as home health aides. The NHI covers inpatient care but not nursing home care. Also, it does not cover preventive health services such as mass screening and health education. Payment to medical providers is made on a fee-for-service basis, where the price of each service is determined by a uniform national fee schedule.

If a participant withdrew from the NHI system because of death, emigration or employment, the withdrawal date and the reason for withdrawal were coded in the NHI withdrawal history files. We recorded any mortality or migration by reviewing the NHI withdrawal history files and collected data on the death of participants by reviewing the death certificates filed at Ohsaki Public Health Center. We then followed up the participants and prospectively collected data on medical care utilisation and its costs for all participants in the cohort from 1 January 1995 through 31 December 2007.

Statistical analysis

We conducted the same analysis as the previous study about the association between walking, life expectancy and lifetime medical expenditure.[16] Briefly, we divided the age groups (×) from 40 years according to the following categories: 40–44, 45–49, 50–54, 55–59, 60,64, 65–69, 70–74, 75–79, 80–84 and ≥85 years. Based on person-years and the number of deaths from 1996 until 2007, the multiadjusted mortality rates for each age category were estimated from a Poisson regression model. The dependent variable was mortality, and independent variables were age groups, categories of BMI and the following covariates: smoking status (current and past smoker or never smoker), alcohol consumption (current drinker consuming 1–499 g/week, current drinker consuming ≥450 g/week or never and past drinker), sports and physical exercise (≥3 h/week or <3 h/week), time spent walking (≥1 h/week or <1 h/week) and education (junior high school, high school or college/university or higher). We did not adjust for hypertension and diabetes mellitus in the multivariate models because these variables are considered to occupy an intermediate position in the etiologic pathway between BMI and mortality.

We separately calculated medical expenditure for participants who survived through the index year and for those who died because previous study showed that medical expenditure increased before death.[20] The multiadjusted medical expenditure per year was estimated using a linear regression model adjusted for the above covariates in survivors and decedents.

The estimates of multiadjusted mortality and medical expenditure were used for estimating life expectancy and lifetime medical expenditure from 40 years of age. To estimate life expectancy and lifetime medical expenditure, we constructed life tables per 100 000 persons using Chiang's analytical method on the basis of the latest published complete life tables of Japan for the year 2000.[21 22] Then, life expectancy (e_x) and lifetime medical expenditure (M_x) for each age groups (x) were estimated using the numbers of survivors (l_x), deaths (d_x), static population (L_x), multiadjusted medical expenditure for survivors (a_y) and multiadjusted medical expenditure for the deceased (b_y) as follows:

$$\sum \text{is sum of} y = x$$

$$e_x = \frac{\sum L_y}{l_x}$$

$$M_x = \frac{\sum(L_y \cdot a_y + d_y \cdot b_y)}{l_x}$$

The 95% CIs were estimated using a Monte Carlo simulation based on a Poisson regression model and linear regression model. We repeated 100 000 times, and all analysis were used the SAS V.9.1 statistical software package (SAS Institute Inc., 2004). All p values <0.05 were accepted as statistically significant.

We used a purchasing power parity rate of UK£ 1.00= JPN\140.[16]

RESULTS

After 13 years of follow-up, we observed 5159 deaths (3356 men and 1803 women) among the 41 965 participants (20 066 men and 21 899 women).

The mean medical expenditure per year for survivors in men was £2393 in underweight, £2055 in normal weight, £2231 in overweight and £2334 in obesity, respectively. In women, it was £2375 in underweight, £1972 in normal weight, £2317 in overweight and £2733 in obesity, respectively. These differences of mean medical expenditure per year for survivors are statistically significant in men and women (ANOVA; p<0.0001). Also, the mean medical expenditure in the year of death for participants in men was £15 445 in underweight, £16 973 in normal weight, £17 811 in overweight and £17 878 in obesity, respectively. In women, it was £12 833 in underweight, £15 584 in normal weight, £17 059 in overweight and £19 635 in obesity, respectively. These differences of mean medical expenditure in the year of death for participants are statistically significant in only women (men, p=0.2241; women, p=0.0059).

Baseline characteristics by BMI category

The baseline characteristics of the study participants according to the BMI categories are shown for men and women (table 1), among whom 3.3% and 3.9% were underweight, 23.6% and 28.4% were overweight and 2.0% and 3.6% were obese, respectively.

Mean age in men decreased linearly with increasing BMI category. In women, mean age was highest in the underweight category. The proportions of men and women who were current and past smokers decreased with increasing BMI, and this tendency was especially marked in men. The proportions of men who had never and past drinker were highest in the underweight category. The proportions of men who did ≥3 h sports and physical exercise per week decreased with increasing BMI. The proportions of men and women who walked ≥1 h/day were the lowest in underweight men and obese women. Educational background increased linearly in men and decreased linearly in women as the BMI category increased. These characteristics showed statistically significant difference.

Mortality in terms of categories for BMI

Figure 1A for men and figure 1B for women show the mortality (per 1000 person-years) in each of the age groups according to the categories of BMI.

In underweight participants, there was a tendency that the mortality was the highest in each age group.

Table 1 Baseline characteristics by BMI categories in 41 965 participants

	Men					Women				
	BMI (kg/m²)					BMI (kg/m²)				
	<18.5	18.5–24.9	25.0–29.9	≥30.0	p Value*	<18.5	18.5–24.9	25.0–29.9	≥30.0	p Value
No. of subjects	666	14 278	4730	392	<0.0001	857	14 031	6226	785	<0.0001
Mean age (years)	64.0	59.1	57.4	56.1		63.7	59.8	60.7	61.2	
SD	10.4	10.5	10.2	10.2		10.9	10.1	9.1	9.5	
Smoking status (%)										
Current and past smoker	87.3	82.5	76.6	74.8	<0.0001	18.6	11.2	10.1	10.6	<0.0001
Never smoker	12.7	17.5	23.4	25.2		81.4	88.8	90.0	89.4	
Alcohol consumption (%)										
Current drinker, 1–449 g/week	49.2	61.0	61.4	50.8	<0.0001	18.2	21.8	21.4	19.3	0.0574
Current drinker, ≥450 g/week	9.6	11.7	12.6	15.0		0.6	0.8	0.5	0.9	
Never and past drinker	41.2	27.3	26.0	34.2		81.2	77.4	78.2	79.8	
Sports and physical exercise (%)										
≥3 h/week	17.5	16.1	13.8	10.1	<0.0001	9.8	11.3	11.0	10.8	0.5993
<3 h/week	82.5	83.9	86.2	89.9		90.2	88.7	89.0	89.2	
Time spent walking (%)										
≥1 h/day	41.7	51.4	45.8	42.7	<0.0001	37.9	45.1	41.0	35.6	<0.0001
<1 h/day	58.3	48.7	54.2	57.3		62.1	54.9	59.0	64.4	
Education (%)										
Junior high school	64.2	62.2	58.9	58.8	0.0013	58.3	54.2	62.7	71.3	<0.0001
High school	27.4	30.5	33.4	33.4		34.0	36.9	31.0	24.6	
College/university or higher	8.4	7.3	7.7	7.8		7.7	8.9	6.3	4.1	

*p Values were calculated by χ^2 test (categorical variables) or ANOVA (continuous variables).
BMI, body mass index.

Overweight participants showed similar mortality with normal weight participants, especially women. Overweight men showed slightly lower mortality than normal weight men. In obese participants, the mortality curve was not described smoothly because of small number of participants.

Table 2 shows the mortality ratio with 95% CIs according to the categories of BMI. In underweight participants, the multiadjusted mortality ratio was significantly higher than that in the normal weight participants (men, 1.62, 95% CI 1.41 to 1.86, p<0.0001; women, 1.46, 1.22 to 1.76, p<0.0001). In overweight participants, the multiadjusted mortality ratio was significantly lower in men and non-significantly lower in women than that in normal weight participants (men, 0.91, 0.83 to 0.99, p=0.0260; women, 0.98, 0.88 to 1.10, p=0.7841). In obese participants, the multiadjusted mortality ratio was non-significantly higher than that in normal weight participants (men, 1.14, 0.88 to 1.49, p=0.3177; women, 1.23, 0.98 to 1.55, p=0.0717).

Life expectancy and lifetime medical expenditure by BMI category

Table 3 shows life expectancy and lifetime medical expenditure with 95% CIs according to the BMI categories.

By multiadjusted analysis, obese men and women had approximately 1.7 and 3.1 years non-significantly shorter life expectancy from the age of 40 years in comparison with men and women of normal weight, respectively (men, p=0.3184; women, p=0.0724). Meanwhile, obese men and women had approximately 14.7% non-significantly higher and 21.6% significantly higher lifetime medical expenditure in comparison with normal weight participants, respectively (men, p=0.1141; women, p=0.0005).

In men, multiadjusted life expectancy was greatest for overweight, that is, 44.34 years (95% CI 43.11 to 45.54, p=0.0264), followed by normal weight (43.03 years, 42.22 to 43.73) and obesity (41.36 years, 38.28 to 44.70, p=0.3184) and was shortest for underweight (37.40 years, 35.80 to 38.87, p<0.0001). The multiadjusted lifetime medical expenditure for overweight was the highest, that is, £114 766.9 (95% CI 107 754.1 to 121 966.6, p<0.0001), followed by obesity (£112 858.9, 94 954.1 to 131 840.9, p=0.1141) and normal weight (£98 355.0, 93 615.3 to 103 010.2) and was the lowest for underweight (£93 208.7, 81 704.9 to 104 706.4, p=0.3916).

In women, multiadjusted life expectancy was greatest for overweight, that is, 52.56 years (50.67 to 54.46, p=0.7797), followed by normal weight (52.31 years,

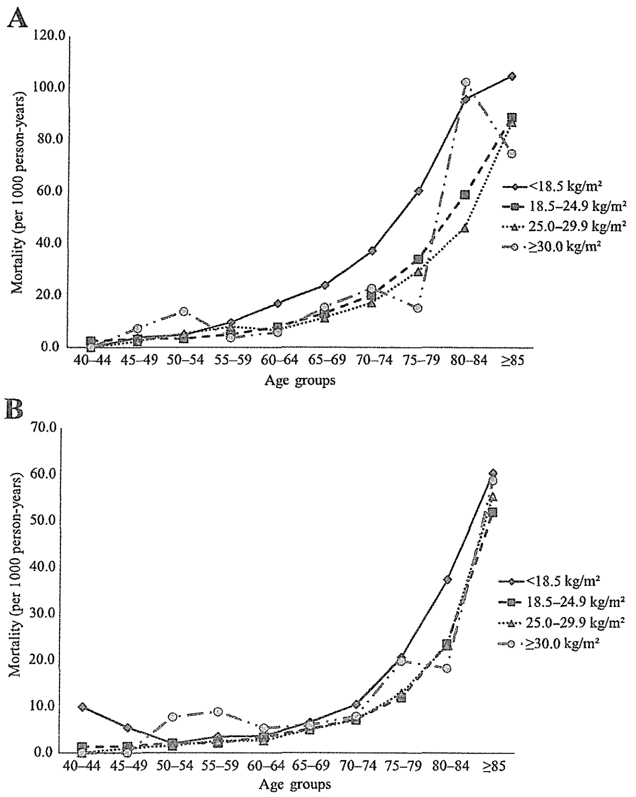

Figure 1 Multiadjusted mortality by BMI categories in each age group in men (A) and women (B).

50.79 to 53.75) and obesity (49.23 years, 46.14 to 52.59, p=0.0724) and was shortest for underweight (46.98 years, 44.63 to 49.29, p<0.0001). The lifetime medical expenditure for obesity was the highest (£137 765.9, 123 672.9 to 152 970.2, p=0.0005), followed by overweight (£129 964.6, 121 845.4 to 138 577.2, p<0.0001) and normal weight (£113 282.9, 106 668.0 to 120 054.6) and was lowest for underweight (£109 382.2, 97 996.6 to 121 008.6, p=0.5174).

DISCUSSION

The present results indicate that (1) obese men and women have 14.7% non-significantly higher and 21.6% significantly higher multiadjusted lifetime medical expenditure than those of the normal weight participants (men, p=0.1141; women, p=0.0005), even though their life expectancy is non-significantly shorter by 1.7 and 3.1 years than those of the normal weight participants, respectively (men, p=0.3184; women, p=0.0724); (2) underweight men and women have 5.2% and 3.4% non-significantly lower lifetime medical expenditure than those of the normal weight participants (men, p=0.5174; women, p=0.3916) because men and women live 5.6 and 5.3 years significantly less than those of the normal weight participants, respectively (men, p<0.0001; women, p<0.0001).

Comparison with other studies

Obese participants had shorter life expectancy than normal weight participants, as has been observed in previous studies.[6–10] Overweight participants had longer life expectancy than normal weight participants. Two of the four previous studies have reported that overweight participants had longer life expectancy than normal weight participants.[7 9] These results support our finding of an association between being overweight and life expectancy. Additionally, an association between BMI and all-cause mortality in the Japanese population has been reported by other data sets.[23–29] All seven previous studies showed that among the BMI categories, the lowest one had the highest mortality risk. These results are consistent with the fact that underweight participants have significantly the shortest life expectancy, as was observed in our study.

Thus, the association between BMI and life expectancy showed same trend with the pooled analyses of the association between BMI and all-cause mortality in Asia and Japan.[30 31]

Our present results support three of the four previous studies of lifetime medical expenditure for obese

Table 2 Mortality ratio for BMI categories in 41 965 participants

	Univariate		Multiadjusted*	
BMI (kg/m²)	Mortality ratio (95% CI)	p Value	Mortality ratio (95% CI)	p Value
Men				
<18.5	1.69 (1.47 to 1.93)	<0.0001	1.62 (1.41 to 1.86)	<0.0001
18.5–24.9	1.00 (Reference)		1.00 (Reference)	
25.0–29.9	0.90 (0.82 to 0.98)	0.0163	0.91 (0.83 to 0.99)	0.0260
≥30.0	1.13 (0.87 to 1.47)	0.3712	1.14 (0.88 to 1.49)	0.3177
Women				
<18.5	1.50 (1.25 to 1.81)	<0.0001	1.46 (1.22 to 1.76)	<0.0001
18.5–24.9	1.00 (Reference)		1.00 (Reference)	
25.0–29.9	1.00 (0.89 to 1.11)	0.9613	0.98 (0.88 to 1.10)	0.7841
≥30.0	1.29 (1.03 to 1.62)	0.0273	1.23 (0.98 to 1.55)	0.0717

*Adjusted for age groups, smoking status, alcohol drinking, sports and physical exercise, time spent walking and education.
BMI, body mass index.

Table 3 Life expectancy and lifetime medical expenditure at age 40 years for BMI categories in 41 965 participants

	Univariate			Multiadjusted*		
BMI (kg/m²)	Estimate	95% CI	p Value	Estimate	95% CI	p Value
Men						
Life expectancy at age 40 years (years)						
<18.5	36.72	35.10 to 38.17	<0.0001	37.40	35.80 to 38.87	<0.0001
18.5–24.9	42.70	41.91 to 43.37	Reference	43.03	42.22 to 43.73	Reference
25.0–29.9	44.09	42.89 to 45.25	0.0157	44.34	43.11 to 45.54	0.0264
≥30.0	41.23	38.16 to 44.54	0.3733	41.36	38.28 to 44.70	0.3184
Lifetime medical expenditure at age 40 years (£)						
<18.5	94 877.5	83 411.4 to 106 275.7	0.6846	93 208.7	81 704.9 to 104 706.4	0.3916
18.5–24.9	97 244.1	92 662.5 to 101 774.0	Reference	98 355.0	93 165.3 to 103 010.2	Reference
25.0–29.9	114 398.2	107 490.1 to 121 505.3	<0.0001	114 766.9	107 754.1 to 121 966.6	<0.0001
≥30.3	115 362.6	97 361.8 to 134 555.0	0.0501	112 858.9	94 954.1 to 131 840.9	0.01141
Women						
Life expectancy at age 40 years (years)						
<18.5	46.26	43.98 to 48.43	<0.0001	46.98	44.63 to 49.29	<0.0001
18.5–24.9	51.70	50.28 to 53.02	Reference	52.31	50.79 to 53.75	Reference
25.0–29.9	51.74	49.98 to 53.48	0.9582	52.56	50.67 to 54.46	0.7797
≥30.0	48.13	45.23 to 51.22	0.0272	49.23	46.14 to 52.59	0.0724
Lifetime medical expenditure at age 40 years (£)						
<18.5	108 278.3	97 142.8 to 119 593.7	0.5816	109 382.2	97 996.6 to 121 008.6	0.5174
18.5–24.9	111 512.8	105 303.4 to 117 910.4	Reference	113 282.9	106 668.0 to 120 054.6	Reference
25.0–29.9	127 869.3	120 236.3 to 135 932.3	<0.0001	129 964.6	121 845.4 to 138 577.2	<0.0001
≥30.0	134 887.1	121 318.4 to 149 383.6	0.0007	137 765.9	123 672.9 to 152 970.2	0.0005

*Adjusted for age groups, smoking status, alcohol drinking, sports and physical exercise, time spent walking and education.
BMI, body mass index.

participants.[10 12 13] In comparison to previous studies, we calculated lifetime medical expenditure from individual medical expenditure and survival data covering longest follow-up period to date. Meanwhile, one study has shown that obese participants have lower lifetime medical expenditure than normal weight participants.[11] However, that study limited the participants to non-smokers and calculated lifetime medical expenditure from the mortality of a hypothetical cohort and estimated medical expenditure from other cohort. In the present study, overweight participants were found to have higher lifetime medical expenditure than normal weight participants, as had been reported previously.[10 12 13] We consider that this was attributable to the higher medical expenditure per month or per person from the 10-year or 9-year follow-up than for normal weight participants.[1 3 4] On the other hand, with regard to underweight participants, our present findings were inconsistent with those of a previous study that examined the association between being underweight and lifetime medical expenditure.[13] However, that study calculated lifetime medical expenditure for elderly participants aged over 70 years. Elderly underweight participants have high mortality,[32] and medical expenditure increases in the 1 year prior to death.[20] Thus, lifetime medical expenditure from 70 years for underweight participants becomes higher than for participants of normal weight. Our study results are thus inconsistent with those reported previously.

We previously calculated life expectancy and lifetime medical expenditure for smokers and non-smokers from age 40 years by using the same data set as that for the present study.[17] The results indicated that lifetime medical expenditure was non-significantly lower in smokers than in non-smokers, reflecting the 3.5 years shorter life expectancy of smokers. On the other hand, the present study indicated that lifetime medical expenditure was higher for obese participants in spite of their shorter life expectancy. This difference would result from the difference in which obesity and smoking affect one's health and longevity. Previous studies of healthy and disability free life expectancy have agreed that smoking shortens life expectancy without affecting the years of life spent with ill-health or disability, while obesity shortens life expectancy and extends the years of life with ill-health or disability.[33] On the basis of these differences, Reuser *et al* summarised the situation as 'smoking kills and obesity disables'.[7] Extended years with ill-health and/or disability must result in increased lifetime medical expenditure. All these findings suggest that weight control would bring about longer life expectancy and long-term enhancement of the quality of life and a cost saving.

Strengths and limitations

A major strength of our present study is that it is the first in the world to have clarified the association between BMI and lifetime medical expenditure calculated from individual medical expenditure and mortality data over

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a long period in a general population from the age of 40 years.[1 14 16–18] The NHI covers almost all medical care utilisation.[1 4 14 16 18] Additionally, in order to reduce bias, we adjusted confounders by including various covariates in our Poisson regression model and linear regression mode.[16] On the other hand, several limitations of our study should also be considered. First, we used self-reported BMI which in a source of error.[34 35] We consider this error to be a non-differential misclassification. This misclassification would lead to attenuation of the true association towards the null. To address this problem, van Dam *et al*[36] studied the association between BMI and mortality using lower BMI cut-off points: 24.5 kg/m^2 to reflect a measured BMI of 25.0 kg/m^2 and 29.0 kg/m^2 to reflect a measured BMI of 30.0 kg/m^2. The association showed similar with original cut-off points. Second, the 95% CI was wide, and there was a limit to the accurate estimation of life expectancy and lifetime medical expenditure for obese participants. Additionally, we did not observe significant association in obese participants without lifetime medical expenditure in women. However, our results are consistent with those of the previous studies.[6–8 10 12 13] In Japan, prevalence of obesity is only 3%.[37] Thus, the reason for non-significant association might be β error because of the lack of statistical power due to small number of obese participants.

Conclusions and policy implication

In summary, even though we observed non-significant association between obesity, life expectancy and lifetime medical expenditure without lifetime medical expenditure in women, lifetime medical expenditure might appear to be higher for obese participants, despite their short life expectancy. With better weight control, more people would enjoy their longevity with lower needs and demands for medical care.

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Competing interests None.

Ethics approval The study protocol was approved by the Ethics Committee of Tohoku University School of Medicine. Participants who had returned the self-administered questionnaires and signed them were considered to have consented to participate.

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