- 現状維持（19.5%）
- 税収（tax）：6水準
  - 20%減少（2,000億円減少）
  - 10%減少（1,000億円減少）
  - 現状維持
  - 10%増加（1,000億円増加）
  - 20%増加（2,000億円増加）
  - 40%増加（4,000億円増加）
- 若年層に対する禁煙施策：2水準
  - 現状通り（強化なし）
  - 強化
- たばこ税の用途：2水準
  - 現状通り（目的を定めず一般財源として使用）
  - 禁煙対策に絞って使用

すべてのパターンを網羅すると5x6x2x2=120パターンとなるが、これを直交計画法を用いて25パターンに整理した上で、個々の回答者にはランダムに13パターンを提示し、それぞれの状況について提示された政策が望ましいと思うか否かを調査した。調査は、アンテリオ株式会社のWebパネルに対して実施した。

質問票の作成にはSPSS19.0を、解析にはSTATA MP11.0を用い、パネルロジットモデルを用いて各因子の寄与を評価した。

（倫理面への配慮）

本研究では、インターネット調査会社にモニター加入している一般人を対象とした。研究者は、個人を特定することができる個人情報にアクセスすることは出来ない。また、調査参加に対して、調査の目的に対する十分な説明がなされ、同意の上での調査への参加となる。

ii) 公共空間、とくに飲食店における禁煙施策の実施が売り上げに与える影響についての過去の研究の整理

受動喫煙の防止の経済的影響として、健康面への影響だけではなく、経済面（売り上げや雇用）への影響の有無が論点となる。健康面への影響については、サーベイ論文も含め多数の研究があるが[2]、経済面での影響に対しての整理したものは少ない。

一般に、医学分野の研究では、経済面での影響は健康面での影響測定に付随的に分析されることが多く、政策前後の売り上げ・雇用を単純に比較したものが多い。

本研究では、経済学研究のデータベースであるEconLitにおいて、売り上げに対する影響を調査した研究を2005年～2012年にかけてサーベイを行った。

（倫理面への配慮）

文献調査のため不要

C．研究結果

i)コンジョイント分析による「理想的タバコ価格の推計」

1,077名が調査を完了した。内訳は、非喫煙者が554名（51.7%），過去喫煙者が186名(17.3%)，現在喫煙者が318名（29.5%)、不明が19名である。

パネルロジット分析の結果として、各因子のロジスティック回帰係数を表1に示す。

すべての因子が、禁煙企図率に有意に影響していた。

税収（1.568)および若年層の禁煙政策強化(1.178)は回帰係数が正に、喫煙率（-1.137)およびたばこ税の目的税化（-0.547)は回帰係数が負になった。すなわち集団の選好としては、税収増加・若年層禁煙対策強化・喫煙率低下・たばこ税の一般財源化がより「好ましい」ことが示された。

喫煙習慣による層別解析では、現在喫煙者が喫煙率に関する回帰係数が正（+0.423)となり、喫煙率の低下を好まないことが示された。

喫煙率と税収は、いずれもたばこの価格弾力性に依存する。すなわち、価格弾力性が-kのもとで、たばこ価格が400円からX円に値上げされた際、喫煙率および税収は以下の式で表現される。

喫煙率：(X-400)÷400×-k
税収：(X-400)÷400×（1-喫煙率の変動幅）

それゆえ、価格弾力性の数値を固定すれば、喫煙率および税収はたばこ価格の関数として表現できる。たばこ価格から喫煙率と税収が定まれば、コンジョイント分析によって得られた式に代入することで、たばこ価格と集団選好の関係を明らかに出来る。価格弾力性を-0.3，-0.4，-0.5に設定して、横軸にたばこ価格、縦軸に集

団選好度合いを描画したグラフを図1に示す。弾力性が-0.5と大きい場合でも、700円程度までの値上げは集団として許容されうることが示された。弾力性が-0.3の場合、理想価格（縦軸の集団選好が最大となる価格)は1,050円程度となった。

ii) 公共空間、とくに飲食店における禁煙施策の実施が売り上げに与える影響についての過去の研究の整理

経済学の専門誌による当該分野の研究は5研究であった。

本分野の研究の端緒となったのは、カリフォルニアの市町村別の受動喫煙防止策の違いを利用して地域のレストランの売上高の影響を分析したFleck and Hanssen(2008)である(3)。

この研究では、以下のように政策と売り上げだかの関係をモデル化している。

- $Y_{i,t} = \alpha + \beta + \gamma Trend_t + \delta Season\_d + \mu_i + \varepsilon_{i,t}$

ただし、

- $Y\_(i,t)$：四半期 t における市町村iのレストランの売上高
- $X\_(i,t)$：喫煙規制の有無（市町村毎）
- $Trend\_t$：時間トレンド
- $Season\_d$：シーズンダミー
- μ_i：市町村固有効果

この研究では市町村レベルでの規制をも分析しているが、州レベルの規制のみを分析対象とすると、トレンド項との相関が高くなり、多重共線性により推定値βの標準誤差が大きくなる。また、規制の影響がラグを経て影響する効果も考えると、出来るだけ長期のデータをとる必要があるといえる。

このようにモデル化しても、フィールド実験のように、政策変更がランダム化されているわけではないので、レストラン売り上げが高くなると、飲食店業界が規制に対してあまり敏感でなくなるので、規制導入という効果を識別することが出来なくなることや、所得は健康意識と外食消費の双方に影響を与えるので第三の要素としてコントロールする必要があるが、市町村ごとの平均所得だけでは不十分であることが推定値にバイアスを与える可能性を議論している。

自治体による制度の変化のタイミングの差を利用して政策評価を検証するアメリカの研究と異なり、ヨーロッパでの研究は、ドイツでの州毎に義務化の有無や罰則規定、除外規定が違うことを利用した研究(4)、2004年3月からのアイルランドでの屋内完全禁煙を検証した研究(5)、2004年6月からのノルウェイでの屋内完全禁煙を検証した研究(6)、2006年3月に施行されたスコットランドでの条例の影響をみるために、条例のない北部イングランドと前後の変化を比べるDifference in Difference（DID）分析がある(7)。それぞれ、おおむね飲食店の売り上げは減少したとの結果が報告されているが、上述のように、長期的なたばこ床減少のトレンドや、地域の差を完全にコントロール出来ておらず、これらの研究は政策効果を過大に推定している影響がある。

D．考察

i)コンジョイント分析による「理想的タバコ価格の推計」

たばこ税の値上げは、税収と喫煙率の双方に影響する。すでに複数の研究で、値上げが税収に及ぼす影響は評価されてきた。しかし公衆衛生の観点からは、単純な税収増加のみならず喫煙率が低下すること自体の価値も合わせて評価すべきである。本研究により、税収と喫煙率の双方について集団の選好度合いが明らかになったことは、今後の値上げを含めたたばこ関連の政策提言に有用である。

たばこ価格と選好度合いとの関連を評価した結果。価格弾力性を最大（-0.5)に見積もっても700円程度までの値上げが許容されうることが示された。喫煙者も含めた集団の選好としてある程度の値上げが選好度合いをむしろ上昇されることは、さらなるたばこ価格の値上げの理論的基盤としても重要と考える。

ii) 公共空間、とくに飲食店における禁煙施策の実施が売り上げに与える影響についての過去の研究の整理

諸外国においても、受動喫煙規制の売り上げに対する影響についての分析は多い。例外的に各店舗への調査による研究があるが、方向性としては、

①州や市町村レベルでの規制タイミングの違いを利用→観察単位は州や市町村　（ミクロ計量

経済学的な研究）
②一国全体での規制の前後比較→観察単位は国　（マクロ時系列分析の研究）
の2つがある。最近では、より高度な分析手法が試されているが、Omitted variable や観察期間の短さなど、効果を結論づけるには不十分といえる。

E．結論
i)コンジョイント分析による「理想的タバコ価格の推計」
　非喫煙者も含めた集団の選好をコンジョイント分析によって評価した。税収増加と喫煙率減少は、どちらも好ましい状況と判断された。たばこ価格とたばこの価格弾力性を変化させた場合、「理想」とされるたばこ価格は、弾力性が-0.5と大きい場合でも、700円程度、弾力性が-0.3の場合では1,050円程度となった。

ii) 公共空間、とくに飲食店における禁煙施策の実施が売り上げに与える影響についての過去の研究の整理

諸外国での研究を見ると、日本での政策保障に関しては、時系列計量分析に基づいた解析、十分長い期間での分析、規制の地域差を確保する必要性、規制のタイミングに与える地域の影響を明示的にコントロール
が必要がある。複数の地域にまたがった研究が出来ないとすると、一つの地域についての影響を中心に分析することとなるが、
その場合でも、その地域と周囲の地域での比較は必須である。また、個票に近い形で売上高（や売り上げを類推できる様な税務データ）を収集することが不可欠である。

F．研究発表
1．論文発表
なし

2．学会発表
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G．知的財産権の出願・登録状況
（予定を含む。）
1．特許取得
特になし

2．実用新案登録
特になし

3．その他
特になし

表1：コンジョイント分析推計結果

全員（N=1,077）

variables	coefficient	standard error	p value	95% CI (lower limit)	95% CI (upper limit)
wholesmoke	-0.654	0.059	0.000	-0.771	-0.538
tax	0.904	0.060	0.000	0.788	1.022
youthpolicy	0.687	0.026	0.000	0.635	0.739
usage	-0.314	0.026	0.000	-0.365	-0.263
constant	-0.360	0.041	0.000	-0.441	-0.279

非喫煙者（N=554）

variables	coefficient	standard error	p value	95% CI (lower limit)	95% CI (upper limit)
wholesmoke	-1.149	0.084	0.000	-1.314	-0.984
tax	1.284	0.084	0.000	1.119	1.449
youthpolicy	0.828	0.038	0.000	0.753	0.902
usage	-0.372	0.036	0.000	-0.443	-0.300
constant	-0.293	0.055	0.000	-0.643	-0.329

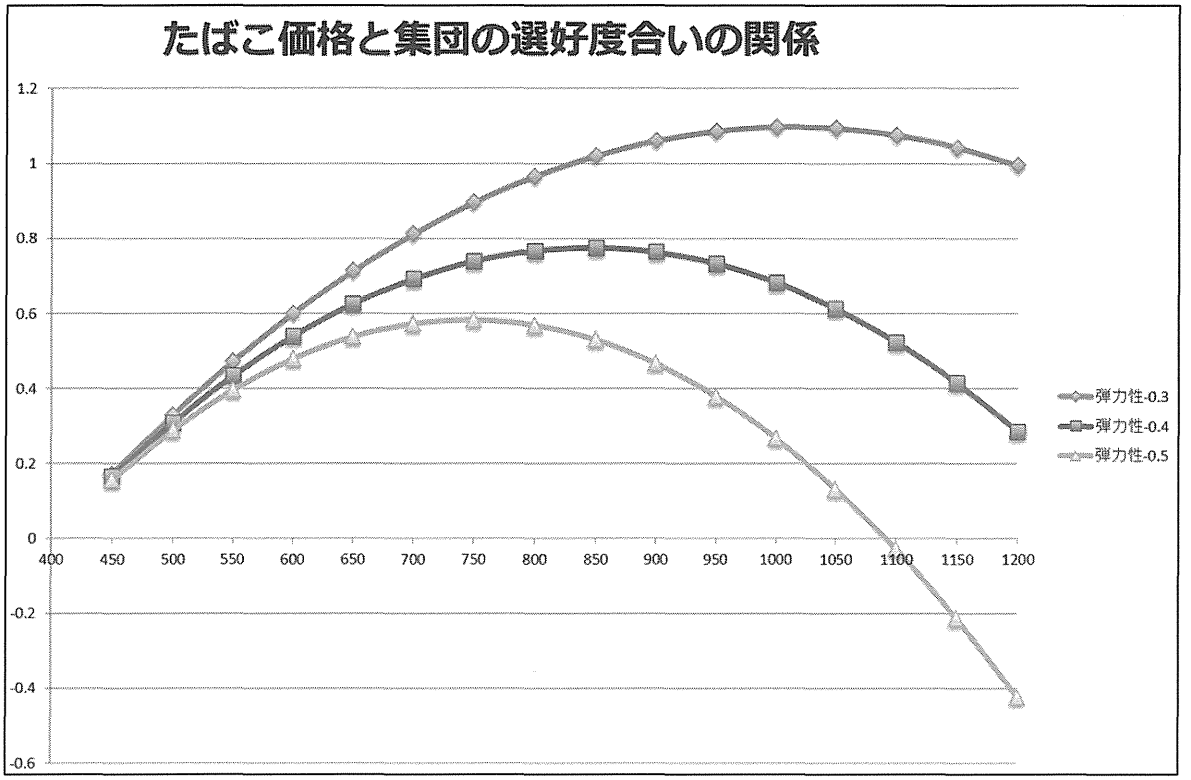
過去喫煙者（N=186）

variables	coefficient	standard error	p value	95% CI (lower limit)	95% CI (upper limit)
wholesmoke	-1.046	0.147	0.000	-1.335	-0.757
tax	0.947	0.144	0.000	0.666	1.229
youthpolicy	0.778	0.064	0.000	0.653	0.904
usage	-0.417	0.063	0.000	0.660	1.229
constant	-0.391	0.098	0.000	-0.582	-0.200

現在喫煙者（N=318）

variables	coefficient	standard error	p value	95% CI (lower limit)	95% CI (upper limit)
wholesmoke	0.423	0.112	0.000	0.203	0.644
tax	0.267	0.112	0.016	0.051	0.489
youthpolicy	0.427	0.049	0.001	0.332	0.522
usage	-0.161	0.049	0.000	-0.258	-0.065
constant	-0.486	0.055	0.000	-0.643	-0.329

図 1


たばこ価格と集団の選好度合いの関係
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
弾力性-0.3
弾力性-0.4
弾力性-0.5

厚生労働科学研究費補助金(循環器疾患・糖尿病等生活習慣病対策総合研究事業)
分担研究報告書

健康格差是正の観点からみたたばこ規制の効果の実証的検証

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研究要旨

研究①：公務員における職場の屋内禁煙化が喫煙行動に与えた影響の評価

目的：本研究の目的は、“男性公務員”および“非喫煙の女性公務員の夫”の喫煙率を各都道府県の一般庁舎における屋内禁煙化導入の前後で比較することにより、禁煙化により禁煙した者の割合を算出し、屋内禁煙化導入の効果を評価することである。

方法：日本を代表するサンプルを有する繰り返し横断調査データを疑似パネル（本研究では同一個人を追跡するわけではないが、例えば2001年調査時の40歳は2010年調査時には49歳であり、同一属性を持つ集団の推移を疑似的にパネルデータとみなす）として用いた。Difference-In-Differences (DID)法による準実験モデル分析を実施した。評価指標は喫煙率の低下（%）である。2001年、2004年、2007年および2010年の国民生活基礎調査個票データから入院入所中の者を除き、勤務先が官公庁であった25-59歳の者を分析対象とした。2011年5月時点に47都道府県のうち、28都道府県（61%）で一般庁舎の屋内禁煙化が実施されていた（2007年までに実施されていたのが12都道府県； 2008年以降に実施されていたのが16都道府県)。19都道府県では分煙であった。屋内禁煙化の導入時期により2003-2007年(早期)もしくは2008-2011年（最近）の2区間に分類した。分析対象者の年齢階層（25-40歳未満、40歳以上）および居住する都道府県の禁煙化状況（分煙、早期の屋内禁煙化、最近の屋内禁煙化の3群）に応じて対象者を層別化し、喫煙率の変化・DID推定値（プラスのDID推定値は屋内禁煙化による禁煙[%]の増加を示す）を計算した。

結果： 分煙と比べた屋内禁煙化の禁煙に与える影響は年齢階層および禁煙化の導入時期によって大きな差が認められた。男性公務員全体における屋内禁煙化のDID推定値は有意ではなく、0（ゼロ）に近かったが、40歳以上の男性公務員では最近の屋内禁煙化において有意に高いDID推定値(5.0 [95%信頼区間:0.2, 9.8])を呈した。非喫煙女性公務員の夫については、40歳以上の早期および最近の屋内禁煙化においてDID推定値（95%信頼区間）は統計学的に有意ではなかったがプラスの値を呈した：それぞれ7.2 (-4.7, 19.2)および8.4 (-2.0, 18.7)であった。

まとめ：分煙と比較して“屋内禁煙化”は、特に最近導入された場合で対象が40歳以上の年齢階層の場合には、男性公務員および非喫煙女性公務員の夫における喫煙を減少させたのかもしれない。しかし、本研究における方法論の限界も大きいため慎重なデータの解釈が必要である。本研究では日本において最も喫煙率が低い集団のひとつである公務員における効果を判定した。喫煙格差の是正の観点から全ての職場における屋内禁煙化が必要だと考えられた。

研究②：タバコ値上げが禁煙の実行に与えた影響の評価

本研究は概要のみの提示に留め、詳細は来年度に報告する。[概要] 国民生活基礎調査と国民健康栄養調査のリンケージ研究により平成22年10月のたばこ値上げによる禁煙の効果を年齢や社会階層別に分析した。日本では値上げ後もタバコ価格が安価な水準に留まるためか、一般に値上げで縮小するとされる社会階層間の喫煙格差が減少する状況は認められず、さらなるタバコ価格引き上げの必要性が示唆された。

研究①：公務員における職場の屋内禁煙化が喫煙行動に与えた影響の評価

A. 背景および研究目的

Tobacco smoking is the most attributable and preventable risk factor for adult mortality and morbidity in Japan [1, 2]. At least ten years of average life expectancy are lost among current smokers in Japan and worldwide [3, 4]. Secondhand tobacco smoke (SHS) is a cause of various illnesses such as neoplastic, respiratory and cardiovascular diseases [5, 6]. It is estimated that annually at least 4,600 non-smoking women die from the effects of SHS in Japan [7]. Partly because the health risks of smoking have become generally known, adult smoking prevalence in Japan has declined recently: i.e., current smoking has decreased from 48% in 2001 to 33% in 2010 among men, and from 14% in 2001 to 10% in 2010 among women [8].

A key intervention in reducing the burden of disease attributable to tobacco use is the smoking ban policy. Along with an increase of population-level knowledge on the risk of SHS, affirmed by the US Surgeon General's Report in 1986, there has been an increase in the number of legislative smoking bans in countries such as Australia, England and the USA [9]. Smoking bans vary in their comprehensiveness by settings, i.e. the extent to which they allow smoking or restrict it to designated areas and where those smoking restrictions occur [9]. In Japan, the Health Promotion Law (HPL) and the Workplace Smoke-free Guideline (WSFG) [10], which promote smoke-free enclosed public places and workplaces, respectively, but allow partial smoking bans as an option, were implemented in 2003 [11], although a partial smoking ban was recommended rather than a complete smoking ban in the WSFG. A partial ban can allow smoking in one part of the same room but not the other and it can also include requirements for smokers and nonsmokers to be separated by a wall and/or different types of ventilation. The partial smoking ban in the WSFG only requires a smoking room where smoke is prevented from leaking into non-smoking space by a ventilation system which directs exhausted smoke outdoors.

A complete indoor smoking ban has been recommended rather than the partial smoking ban, especially after ratification of the World Health Organization Framework Convention on Tobacco Control (FCTC) by the Japanese government in 2005. The spaces the HPL designated as smoke-free environments include schools, hospitals, gymnasiums, department-stores, restaurants and public offices, but the execution level of the complete indoor smoking ban differs considerably by setting. For example, the execution rate of the complete indoor smoking ban was 97% in public schools in 2012 [12], but 27% in restaurants in 2011 [13]. Because the law has no penalty for non-compliance, some jurisdictions, such as Kanagawa and Hyogo prefectures, recently implemented their own

legislation for public smoking bans which includes penalties [11]. Even in public offices, therefore, there are many varieties in the execution of complete indoor smoking bans by prefectures in Japan. However, because the legislation in Kanagawa and Hyogo came into operation very recently in April 2010 and April 2013, respectively, we could not evaluate the effect of the legislation on smoking and have focused on the situation before the prefecture-based legislation era in Japan.

Although the main reason for workplace smoking bans is to protect nonsmokers from the harmful health effects of exposure to SHS at work, an incidental impact is to provide a supportive environment for people who want to quit smoking [14]. The diffusion theory [15] suggests that the smoke-free norm of a workplace smoking ban policy can disseminate into adjacent environments such as the home; the workplace smoking-ban may therefore affect not only employees but also their families. From the public health perspective, these may provide beneficial impacts [9].

Our objective in this study was to assess the difference in smoking prevalence under different smoking ban policies such as a complete workplace indoor smoking ban and a partial smoking ban among male public workers and husbands of female non-smoking public workers, before the prefecture-based legislation era in Japan.

B. METHODS

Study subjects

We used pseudo-cohort data from nationally representative cross-sections which collect information from all household members on health-related factors, such as smoking behavior, every three years: the 2001, 2004, 2007 and 2010 Comprehensive Survey of Living Conditions of People on Health and Welfare, conducted by the Japanese Ministry of Health, Labour and Welfare (MHLW) [16]. To assess the impact of the smoking ban policy in public offices, we used subsamples of male public workers and husbands of female non-smoking public workers. To interpret the causal inference between a workplace smoking ban and smoking by husbands more easily, husbands who worked at public offices were excluded from the analysis for husbands' smoking. Data were used with permission from MHLW.

Intervention: Smoking ban in Japanese governments' buildings

The execution of a complete indoor smoking ban policy, but no partial smoking ban, in a prefectural government administration building was used as an exogenous proxy indicator for a hypothetical legislative public office smoking ban intervention. To date, previous studies that examined smoking ban legislation and smoking behaviors with consideration of factual execution are scarce [9, 17]. This may be due, in part, to the high level of execution in a number of countries such as Australia, Scotland and the Netherlands [18-20]. However, it may be appropriate to evaluate smoking ban policy by execution level, as this

could reduce underestimation, especially in low execution level countries including Japan [21]. Although Japan implemented HPL and WSFG as well as FCTC for promoting a smoke-free environment, execution of the complete indoor smoking ban remained low, even in government administration buildings, against a target of 100% complete indoor smoking ban.

In 2000, 42 out of 47 prefectural government offices executed partial smoking bans and five allowed smoking in the workplace [22], although we had no specific data for these five prefectures. To investigate the local situation for smoking ban policy across Japan, Yamato and colleagues conducted a mail survey of Japanese local government buildings (including 47 prefectural government offices, 46 prefectural capital municipality offices, 23 wards in Tokyo and 5 other metropolitan cities) in 2007, 2008, 2010, 2011 and 2013 (response rates were 100% because of intensive reminder notice) [23]. The execution date of the complete indoor smoking ban in governmental building was reported. Of 47 prefectures only 61% executed a complete indoor smoking ban in government office buildings instead of a partial smoking ban in June 2011, although no prefecture allowed smoking in working areas. Based on the implementation period of the complete indoor smoking ban in the building, we classified prefectures into three categories: "Partial smoking ban (reference area)" where smoking was allowed in designated rooms or areas in June 2011; "Early smoking ban" where the prohibition of indoor smoking started between 2003 and 2007 and continued; and "Recent smoking ban" where the ban started between 2008 and 2011. Forty seven prefectures in Japan were categorized as follows; "Partial smoking ban": Aomori, Iwate, Fukushima, Gunma, Tokyo, Niigata, Ishikawa, Gifu, Shizuoka, Aichi, Mie, Tottori, Hiroshima, Nagasaki, Kumamoto, Oita, Miyazaki and Kagoshima; "Early smoking ban": Yamagata, Ibaragi, Saitama, Kanagawa, Yamanashi, Nagano, Osaka, Hyogo, Yamaguchi, Kochi, Saga and Okinawa; "Recent smoking ban": Hokkaido, Miyagi, Akita, Tochigi, Chiba, Toyama, Fukui, Shiga, Kyoto, Nara, Wakayama, Shimane, Okayama, Tokushima, Kagawa, Ehime and Fukuoka. This information was merged with the survey data on the basis of subjects' prefecture of residence. Because the decision regarding the smoke-free policy had been made prior to its execution and had potential impact prior to its implementation (e.g., via anticipation effects) [24], data from May 2003 to May 2011 were used in the study.

Smoking outcome

The outcome was current smoker prevalence among male employees and husbands of female nonsmoking employees, because there were few female smokers. Current smokers were defined as persons who smoked cigarettes regularly at the time of survey. Smoking behavior was surveyed based on the following four categories: (a) "I don't smoke"; (b) "I smoke every day"; (c) "I smoke occasionally but not every day"; and (d) "I have

stopped smoking for more than one month". We categorized (b) and (c) as current smoker. Unfortunately, the information on former smokers (d) was biased [25], potentially because many quitters selected (a) instead of (d); so we could not use this variable to estimate smoking cessation rates. However, current smoker prevalence was reliable because this was consistent with current smoker prevalence in another Japanese representative study of the National Health and Nutrition Survey [25].

Statistical analysis

Because Japanese people typically retire at 60 years and over, subjects aged 25 years at baseline and up to 59 years in the follow-up period were analyzed by pseudo-cohort methods [26]: for example, persons aged 25-50 years in 2001 were aged 34-59 years in 2010 (Figure 1). Japanese adults aged over 25 years were less likely to start smoking [27], and therefore decreases from pre- to post-current smoker prevalence could be assumed as smoking cessation rates. To evaluate the effect of a complete indoor workplace smoking ban (intervention) on smoking behavioral changes, a difference-in-differences (DID) estimate was calculated by subtracting post (follow-up) outcome rate from pre (baseline) outcome rate in the intervention and reference groups [16, 28]:

$$\mathrm{DID} = \mathrm{difference}_{\mathrm{intervention}} - \mathrm{difference}_{\mathrm{reference}}$$

The positive value of the DID estimate represents the smoking cessation percentage, while the negative value may indicate that of relapse of smoking. Since different tendencies for the health-related behavior between the old and the young were expected [29], we stratified subjects over and under 40 years in baseline with each group representing roughly half of the sample.

Firstly, we compared smoking rates between 2001 and 2010. Next, other time periods such as 2007-2010 were analyzed to validate the result (Figure 1). Furthermore, to compensate for methodological weaknesses which arose from the lack of consideration of background differences between pre- and post-characteristics, confounding factor (such as marital status and housing tenure)-adjusted DIDs were implemented as a sensitivity analysis (see supplementary data). Probability values for statistical tests were two tailed, and $p<0.05$ was regarded as statistically significant. All statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC).

C. RESULTS

Data were available for 247,195 (response rate: 87.3%) households in 2001, 220,836 (79.8%) in 2004, 229,821 (79.9%) in 2007 and 228,864 (79.1%) in 2010. Of these, subsamples of male public workers (n=10,143-12,791 in 2001, 7,922-9,188 in 2004, 8,416-8,972 in 2007 and 6,840-7,750 in 2010) and husbands of female non-smoking public workers (n=1,449-1,913 in 2001, 1,499-1,853 in 2004, 1,996-2,217 in 2007 and 1,994-2,174

in 2010) were analyzed (Figure 1). Sample numbers in 2001 and 2010 according to the smoking ban categories and characteristics are shown in Table 1 and supplementary Table S1 and S2.

Current smoker prevalence, the decrease and DID estimates (effect sizes) among male public office workers according to smoking ban categories are shown in Table 2. Current smoker prevalence decreased from 46.4% in 2001 to 31.6% in 2010 among total male workers. It could be assumed that 14.8% (31.9% of smokers) men stopped smoking during 2001-2010. DID estimates for early and recent smoking bans were not significant among total men: 0.9 (95%CI: -3.0, 4.7) and 1.8 (-1.5, 5.2), respectively. The over 40s age groups indicated significant DID estimates of 5.0 (0.2, 9.8) for the recent smoking ban, although the younger groups did not show significant DID estimates for either smoking ban.

Table 3 shows current smoker prevalence, the decrease and DID estimates among husbands of female nonsmoking public office workers according to smoking ban categories. Spousal (husbands') smoking prevalence decreased from 52.7% in 2001 to 34.9% in 2010 among total female nonsmokers. It could be assumed that 17.8% (33.8% of spousal smokers) husbands stopped smoking during 2001-2010. DID estimates for early and recent smoking bans on spousal smoking was not significant among total female workers. The over 40s age group indicated positive DID estimates for early and recent smoking bans of 7.2 (-4.7, 19.2) and 8.4 (-2.0, 18.7), respectively, although these were not statistically significant.

Table 4 shows DID estimates by several periods before and after 2007, such as 2007-2010, according to smoking ban categories. As for the recent smoking ban, after 2007, the DID estimate among the over 40s was significant for male current smoking and not statistically significant but had a positive value for spousal smoking; 5.7 (1.5, 10.0) and 4.6 (-3.5, 12.7), respectively, although those were nearly zero before 2007. The early smoking ban showed DID estimates for male current smoking were around zero with small range, while those for spousal smoking showed positive values among the over 40s, especially after 2004 including 2004-2010. DID estimates for 2004-2010 were rather higher than those for other time periods for both recent and early smoking bans, particularly among the over 40s; i.e., statistically significant results of 5.5 (0.9, 10.1) for recent smoking ban among over 40s male workers, 11.8 (3.2, 20.5) for early smoking ban among husbands of all female workers, 13.6 (2.6, 24.6) for early smoking ban among husbands of over 40s female workers and 11.0 (1.7, 20.2) for recent smoking ban among husbands of over 40s female workers. Furthermore, the sensitivity analysis showed smoking-related factors-adjusted DID results did not largely differ (data not shown).

D. DISCUSSION

There is insufficient evidence as to whether a complete smoking ban decreases tobacco use compared with a partial smoking ban [9]. We found that the complete workplace indoor smoking ban, particularly that recently implemented among over 40s public office workers, decreased workers' smoking prevalence compared with a partial ban, especially after 2007. This result of decreased prevalence following a workplace smoking ban is in line with previous studies [14], suggesting a new aspect of the comparison between a complete smoking ban and a partial smoking ban. We also found the workplace smoking ban indicated positive values, although mostly non-significant, on the decrease of husbands' smoking prevalence among over 40s female nonsmoking workers compared with a partial ban. This may imply an increase in smoke-free homes after the implementation of a workplace smoking ban among over 40s female nonsmoking workers. This is in line with previous studies that found smoke-free legislation stimulated the adoption of smoke-free homes [30]. The workplace smoking ban may have a beneficial impact on smoking workers, nonsmoking workers and their families. However, our findings remain tentative because of limited significant results and methodological weaknesses in this study.

In the WSFG in 2003 [10], construction of a comfortable working environment was highlighted rather than workers' health. However, workers' health harm reduction was prioritized in a recent report for workplace smoke-free policy by the MHLW in 2010 [31]. In the context of the new report and the HPL [11] in Japan, all employers have a responsibility and statutory duty to provide and maintain a working environment which is safe and free from risks to health including SHS exposure. Although we only accessed public office workers in the study, generally, the most heavily exposed and most at risk are those working in the hospitality industry such as bar workers, waiters and waitresses [32]. Intake of SHS in bar staff can be four times higher than that arising from living with at least one smoker [33]. The health risks to these employees are therefore especially high, and need to be prevented. Governments initially tend to implement the law affecting only public or unavoidable places [32]. This may widen the degree of inequality in the smoking ban between public and non-public places, although compliance with the law is also important. Thus, from the equity perspective, complete smoking ban policies for all workplaces, including not only public office but also the hospitality industry, must be required.

Unlike the USA where tobacco taxation differs by states, the same cigarette price is applied throughout Japan and there are no media anti-smoking campaigns [11]. Therefore, the impact of these measures which are most influential factors on smoking behavior could be ignored as a strength of this study. Simultaneously, the underlying downward trend in smoking prevalence

observed between 2001 and 2010 could be taken into account by the DID method [16].

Workplace smoking ban and husbands' smoking

A workplace smoking ban may increase awareness of the dangers to nonsmokers of SHS, and help establish norms regarding the inappropriateness of smoking around nonsmokers. The norm of unacceptable smoking around nonsmokers, resulting from compliance with the indoor smoking ban policy, might influence people to adopt such rules voluntarily for their homes [14], and might improve husbands' smoking cessation by enhancing conjugal support and communication [34]. Thus, the mechanism between the workplace smoking ban and home smoking behavior may decrease husbands' smoking.

In a previous review, workplace smoking bans were deemed to have a smaller effect on smoking behavior than home smoking bans in studies that analyzed both workplace and home smoking bans simultaneously [14]. However, according to the above mechanism, voluntary home smoking bans may mediate between workplace smoking bans and smoking behavior. Thus, the adjustment for home smoking bans may result in underestimation of the effect of workplace smoking ban; i.e., although the variable of home smoking ban was not used in the current study, it may be appropriate for evaluation on the effect of a workplace smoking ban.

Effect modifications

In this study, large age group differences in the effect of a smoking ban on smoking behaviors were seen. Generally, smoking cessation may be more difficult for older than for younger adults, because of a longer duration of smoking and thus a stronger nicotine dependence. However, the observed age group difference in the study is not surprising, because older people are more likely to conduct healthy behavior change than younger people [35]. Although few previous studies have examined the smoking ban using age group stratification, a lower effectiveness of smoking restrictions among young populations was observed [36], consistent with this study. Johnson et al. note that older people are more likely than young people to try to avoid unnecessary risks owing to their accumulated experience of health risks over a lifetime [35]. Another reason for the age group differences might be similar to resistance to the smoking ban by adolescents who start smoking as a form of rebellion [37], and thus a positive effect of smoking ban was not observed among the under 40s. Furthermore, different personal compositions, such as age and housing tenure, might cause a difference, although the results of sensitivity analyses adjusting these covariates did not materially differ.

In terms of difference due to implementation period, the effect of recent smoking ban was observed, particularly in 2007-2010, although the effect of the early smoking ban, which was implemented in 2003-2007, was not stable (Table 4). This

might be due to a potential interaction. The smoking ban was one component of a multi-component effort to reduce tobacco use. The prefectural execution of the complete indoor smoking ban might occur during a period when other tobacco control strategies were relatively steady in the prefecture. A recent smoking ban might have a better interaction effect with a recently improved environment which promotes smoking cessation than an early smoking ban, because population norms against smoking had been reinforced by recent other tobacco control measures such as increased tobacco taxation and improved cessation assistance [11]. Thus, it is not generally possible to attribute all changes in smoking behavior to the smoking ban.

In terms of husbands' smoking, a wide range of baseline smoking prevalence by stratified categories might result in unstable DID estimates with limited significance. This might be due to chance and small sample size.

Limitations

There are several other limitations in the study. First, smoking outcomes were self-reported without biomarker validation, but the reliability of self-reporting smoking behavior was generally high [38]. Second, because this study is based on repeated cross sections instead of longitudinal data, changes in one individual could not be specified. Therefore, results may be biased by accidental distributions between different years. Longitudinal studies, however, have the problem that disadvantaged people are likely to leave the study. In this study, all respondents with characteristics of disadvantage could be included. Furthermore, the prefecture-based proxy indicator, which was used for intervention identification, may also lead to an ecological fallacy, an accident or underestimation by misclassification. Third, because public workers were studied, the ability to generalize from the results might be limited. The smokers in public offices might be more susceptible to pressure to change their behavior [14]. Therefore, this may lead to overestimation. Fourth, the execution of the smoking ban was not random. For example, Kanagawa prefecture implemented its own legislation to provide a smoke-free environment. In some cases, it has been argued that antismoking sentiments drove the passage of the law and reductions in smoking behaviors. We could not control for antismoking sentiments in the population, although strong leadership on making-decision by local governors was believed to be important for the implementation of legislation in Japan [39].

E. Conclusions

We examined whether a workplace complete indoor smoking ban would reduce male workers' smoking and female workers' husbands' smoking, compared with a partial ban, among Japanese public workers. The effectiveness of smoking bans considerably varied by age and period. A complete workplace indoor smoking ban, particularly one recently implemented among public office

workers aged over 40, may reduce male workers' smoking and female workers' husbands' smoking compared with a partial ban, although other categories indicated weak, negative or no impact on smoking cessation.

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Acknowledgment

We thank Dr. A. Oshima and Dr. M. Nakamura for valuable comments. We also thank Dr. J. Mortimer for her English language editing. This study was supported by the Ministry of Health, Labour and Welfare (Grant; Comprehensive Research on Life-Style Related Diseases including Cardiovascular Diseases and Diabetes Mellitus (H25-010)).

Disclosure

The authors have declared no conflicts of interest.

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Supplementary data

Supplementary methods

Sensitivity analysis

The impact of the intervention on smoking outcomes was estimated by unadjusted difference-in-differences (DID). However, crude comparisons of pre- and post-outcomes may be contaminated by the effect of biased characteristics that differ between the two groups. Thus, we applied the confounding factors-adjusted DID [1, 2] as a sensitivity analysis. Factors related to smoking behavior were used to present characteristics of study subjects and to control for their possible confounding effects. In line with previous studies [3-5], we used (i) age group, (ii) marital status (married, never married or widowed/divorced), (iii) housing tenure (yes/no), (iv) equivalent household expenditure in a month (tertile) and (v) living in metropolitan areas (yes/no).

Supplementary results

Analyzed sample numbers (period 2001-2010) according to basic characteristics are shown in supplementary Table S1. Nationally representative 16,983 male public employees (10,143 in 2001 and 6,840 in 2010) and 3,443 married non-smoking female public employees (1,449 in 2001 and 1,994 in 2010) were analyzed. The figures in 2001-2010 were slightly smaller than sample size of other periods such as 2007-2010 (data not shown), because the usable age range (age of 25 years in baseline and up to 59 years in follow-up period) was narrower in 2001-2010 than in other periods such as 2007-2010. Basic characteristics according to smoking ban categories are shown in Table S2. There was no large difference in distribution of age group, marital status or metropolitan area by smoking ban category. On the other hand, some differences in those of home owner and equivalent household expenditure were observed, but there is no consistent tendency by smoking ban category.

Sensitivity analysis

The confounding factors-adjusted DID estimates did not largely differ compared with unadjusted DID estimates in Table 4, although the model complexity in the adjusted DID resulted in a wide confidential interval (data not shown).

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F.研究発表

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G. 知的財産権の出願・登録状況

（予定を含む。）

1. 特許取得

特になし

2. 実用新案登録

特になし

3. その他

特になし