The effect of a smoking ban on exposure and cardio-respiratory health of non-smoking hospitality workers in Switzerland

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Basel, den 18. Juni 2013

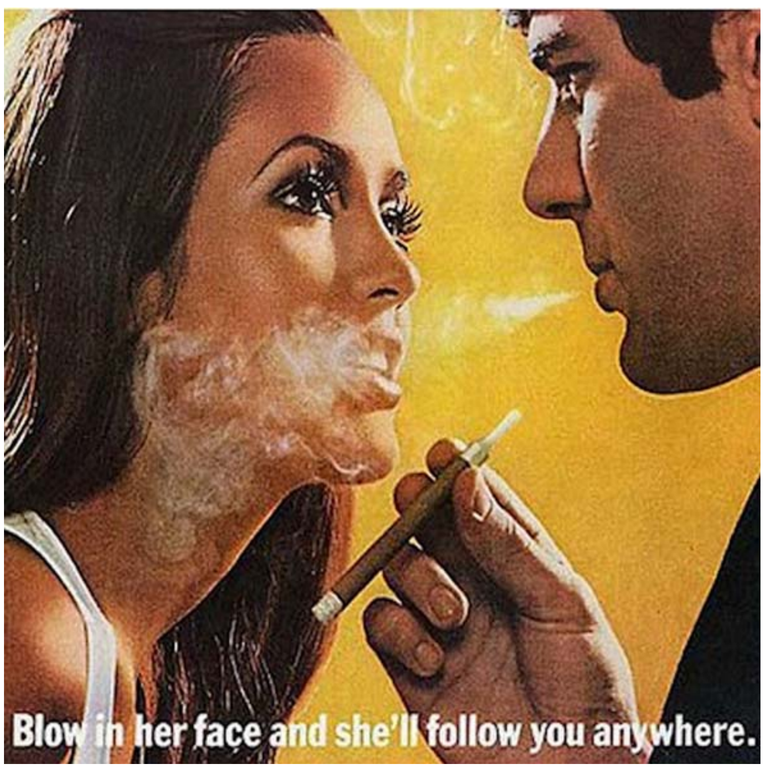
Prof. Dr. Jörg Schibler

Dekan

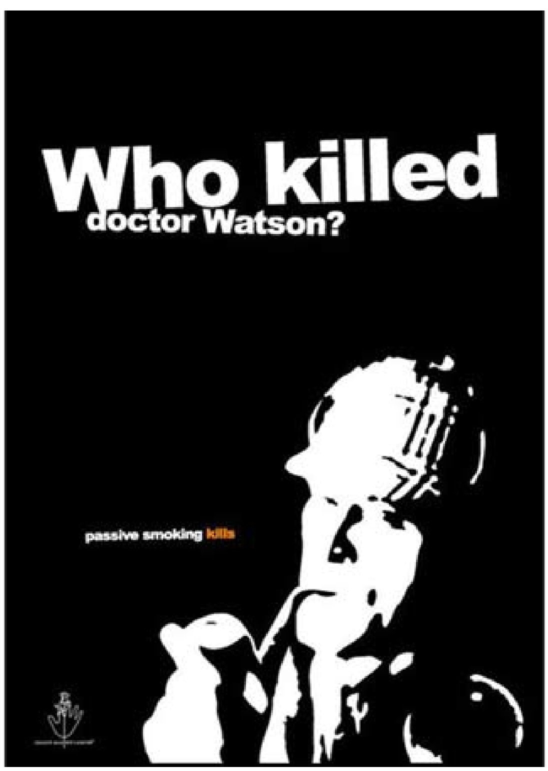
To my father,
my mother
and my sister

Passive smoking

then…



...and now



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Abbreviations

AHV	Old-age and Survivors Insurance (Switzerland)
AMI	Acute Myocardial Infarction
ANS	Autonomic Nervous System
APDRG	All Patient Diagnosis Related Groups
BAT	British American Tobacco
CAVI	Cardio-Ankle Vascular Index
CHF	Swiss Francs
CI	Confidence Interval
COPD	Chronic Obstructive Pulmonary Disease
COSIBAR	Cohort Study on Smoking Interventions in Bars and Restaurants
CE/d	Cigarette Equivalents/day
ECG	Electrocardiogram
EKBB	Ethics Committee of Basel, Switzerland
ETS	Environmental Tobacco Smoke
FCTC	Framework Convention for Tobacco Control
$FEF_{25\%-75\%}$	Forced Expiratory Flow 25-75%
FeNO	Fractional Exhaled Nitric Oxide
FEV_1	Forced Expiratory Volume in 1 Second
FOPH	Federal Office of Public Health
FVC	Forced Vital Capacity
HIA	Health Impact Assessment
HF	High Frequency
HRV	Heart Rate Variability
IARC	International Agency for Research on Cancer
IV	Disability Insurance (Switzerland)
JT	Japan Tobacco
LF	Low Frequency
MoNIC	Monitor of Nicotine
NCD	Non-Communicable Disease

$PM_{2.5}$	Particulate Matter smaller than 2.5 micrometers
PM_{10}	Particulate Matter smaller than 10 micrometers
PWV	Pulse Wave Velocity
SDNN	Standard Deviation of N-N Intervals
SHS	Second hand Smoke
SIDS	Sudden Infant Death Syndrome
SPSS	Statistical Product and Service Solutions
SRNT	Society for Research on Nicotine and Tobacco
Swiss TPH	Swiss Tropical and Public Health Institute
RMSSD	Root Mean Square of Successive Differences
TFI	Tobacco Free Initiative
TP	Total Power
TPF	Tobacco Prevention Fund
UK	United Kingdom
USA	United States of America
VLYL	Value of a Life Year Lost
VOC	Volatile Organic Compounds
WHA	World Health Assembly
WHO	World Health Organization
YLL	Years of Life Lost

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Summary

Background

The first scientific studies on negative health effects of passive smoking published in the 1980s instigated an intense battle between the tobacco industry, who fear the loss of social acceptance of smoking and resultant financial damages, and diverse interest groups defending the health of the non-smoking population. In 2003 the World Health Organisation issued a Framework Convention for Tobacco Control, which was signed by 168 member states and has been ratified by 176.

Since then, several countries have implemented smoking bans in public indoor spaces and workplaces. At the same time studies on second hand smoke (SHS) exposure and related health effects in hospitality workers have been conducted using various, albeit unreliable, methods. For example, exposure is typically assessed by means of a questionnaire or by measuring a proxy such as $PM_{2.5}$. Likewise, measuring nicotine in biological samples such as urine, blood or saliva may be influenced by personal metabolism. Most health-related studies focus on respiratory examinations and have completely neglected long-term effects of SHS exposure on cardiovascular health. This study aims to address some of these knowledge gaps.

In May 2010 Switzerland implemented the first national smoking ban to protect the population from passive smoking. Loose regulation left room for exceptions; there remained a possibility to establish small smoking venues or separate smoking rooms of limited size. The COSIBAR study utilized the transition as a natural intervention to examine exposure and the cardio-respiratory health of non-smoking hospitality workers.

Methods

An intervention group that experienced a change in smoking regulation was to be compared with a control group that continued to work in a smoke-exposed environment. To this end, the air was measured in 193 hospitality venues before the ban in the cantons of Basel City, Basel County and Zurich. 92 workers were recruited and invited to three medical examinations, once before implementation of the ban and twice afterwards. Exposure was also measured each time, and at the first and second time points a questionnaire on behaviour and acceptance was mailed to participants. In this non-medical target group also smokers were included.

Exposure was measured by means of a passive nicotine-specific sampler. One was placed at the workplace for a week and a second one was worn by the participants for a personal 24-hour measurement. In addition, we took a salivary sample during the medical examination to determine nicotine and cotinine content. A questionnaire contained further questions on personal exposure.

Height, weight and blood pressure were measured in the medical component. We did an ECG to assess heart rate variability (HRV)- a quantitative marker of autonomic activity of the nervous system. We also measured pulse wave velocity (PWV) to determine arterial stiffness which is an indicator of cardiovascular risk factors and atherosclerosis. Respiratory health was examined by measuring lung function and fractional exhaled nitric oxide (FeNO), an inflammatory marker in the lungs. Furthermore we did an allergy test at baseline and performed an extensive interview at each appointment.

To analyse the health data we developed several models; exposure was compared to all health parameters in a cross-sectional baseline analysis. A longitudinal model correlated exposure at every time point with corresponding health data taking into account within-subject correlation. Finally, a pre/post comparison of health parameters was done without taking exact exposure into account. All models were adjusted for appropriate covariates.

The behaviour and acceptance questionnaire contained questions on personal knowledge and attitude towards the smoking ban and factors influencing these as well as on smoking status and behaviour. Responses were analysed with suitable statistical tests.

Results

Average SHS exposure in the intervention group decreased by 2.4 cigarette equivalents/day (CE/d) after the smoking ban while the change in the exposed control group was significantly smaller.

In the cross-sectional analysis of the baseline data we found that mean lung function of all exposed hospitality workers was below the recorded average for the Swiss population. FeNO values were directly associated with exposure, meaning we observed decreased inflammation with increased exposure.

In the longitudinal model that compared exposure to health measures, several HRV parameters significantly correlated with exposure. A decrease by one unit CE/d was linked to an increase in the root mean square of successive differences (RMSSD), the standard deviation of N-N intervals (SDNN), high frequency (HF) and Total Power (TP) as well as a decrease in PWV. These associations were consistent with the original hypothesis that predicted better health with lower exposure.

In the pre/post model not taking exact exposure into account, there was a significantly different development of several parameters in the intervention group compared to the control group. SDNN, RMSSD, HF and TP increased in the intervention group while decreasing in the control group. The inverse was true for the low frequency/HF ratio (LF/HF), an effect that also corresponded to our expectations. FeNO decreased in the intervention group, while the control group showed a significantly different slight increase. No changes could be observed in lung function.

Acceptance of the smoking ban was higher in non-smokers than in smokers throughout the study. It rose from baseline to follow-up in both groups in the canton of Basel Land which had a comprehensive smoking ban in place but not in the two other cantons that had a regulation allowing exceptions.

Discussion

In this study there were clear indications for an improvement of cardiovascular health in non-smoking hospitality workers after implementation of a smoking ban.

Risk factors for myocardial infarction or arteriosclerosis had significantly decreased in the intervention group. No change in lung function was observed while FeNO showed a decrease that cannot be considered clinically relevant. Hence, heart rate variability and pulse wave velocity seem to be the most sensitive markers, while lung function may take longer to recover or may remain irreversibly damaged. FeNO is influenced by many factors and is in need of further research.

All these results speak for a comprehensive smoking ban without exceptions. The higher acceptance that we observed with this type of regulation further supports this recommendation.

Nevertheless an initiative by the lung association demanding exactly this consolidation of the law was rejected in September 2012. During the animated voting campaign, first study results were published. The failure of the campaign raises the question if health is an attractive political argument when personal freedom of decision is threatened. What more, the tobacco industry holds a powerful position as an important employer and tax payer in Switzerland and its role must be considered and moved into the people's conscience. The alleged personal freedom of Swiss citizens to decide on their smoking behaviour seems to be an illusion, caused by concealed brainwashing by the world's most manipulative industry.

Zusammenfassung

Hintergrund

Seit in den 1980er Jahren erste wissenschaftliche Studien die negativen gesundheitlichen Folgen von Passivrauchen nachgewiesen haben, herrscht ein unerbittlicher Kampf zwischen der Tabaklobby, die den Verlust der sozialen Akzeptanz des Rauchens und damit verbundene finanzielle Einbussen fürchtet, und verschiedenen Interessengruppen, die sich für die Gesundheit der nichtrauchenden Bevölkerung einsetzen. Die Weltgesundheitsorganisation erliess 2003 ein Rahmenübereinkommen zur Eindämmung des Tabakkonsums, das von 168 Staaten unterschrieben und inzwischen von 176 ratifiziert wurde. Seither wurden in mehreren Ländern Rauchverbote in öffentlichen Räumen und an Arbeitsplätzen eingeführt. Dabei wurden oft Studien zu Rauchexposition und Gesundheitsfaktoren von Gastgewerbemitarbeitern durchgeführt, mit unterschiedlichen Methoden. Die Exposition wurde meistens anhand von Fragebogen oder unter Anwendung eines Proxys wie $PM_{2.5}$ eingeschätzt, was jedoch ungenau sein kann. Die Nikotinmessung von biologischen Proben wie Urin, Blut oder Speichel kann ausserdem vom persönlichen Metabolismus beeinflusst werden. Bezüglich der Gesundheit konzentrierten sich die meisten Studien auf respiratorische Untersuchungen und vernachlässigten kardiovaskuläre Langzeitauswirkungen der Passivrauchexposition völlig. Mit dieser Studie sollten einige dieser Lücken gefüllt werden.

Im Mai 2010 wurde in der Schweiz das erste Bundesgesetz zum Schutz der Bevölkerung vor Passivrauchen eingeführt. Da die lose Regelung Raum für Ausnahmen liess, war es weiterhin möglich, kleine Raucherlokale oder abgetrennte Rauchräume von begrenzter Grösse, zu führen. Die COSIBAR Studie nutzte die Umsetzung als natürliche Intervention für eine Untersuchung der Exposition und kardio-respiratorischen Gesundheit bei nichtrauchenden Gastgewerbemitarbeitern.

Methoden

Eine Interventionsgruppe, die eine Änderung der Rauchregel erfuhr, sollte mit einer Kontrollgruppe verglichen werden, die weiterhin im Rauch arbeiten musste.

Dazu wurde vor dem Rauchverbot die Luft in 193 Betrieben in den Kantonen Basel Stadt, Basel Land und Zürich gemessen. 92 Mitarbeiter konnten rekrutiert werden und wurden zu drei medizinischen Untersuchungen eingeladen, einmal vor Einführung des Rauchgesetzes und zweimal danach. Parallel wurde jeweils die Exposition gemessen, sowie beim ersten und zweiten Erhebungszeitpunkt ein Verhaltens-und Akzeptanzfragebogen verschickt, in dessen Zielgruppe auch Raucher eingeschlossen wurden.

Die Exposition wurde mit Hilfe eines passiven Nikotinbadges gemessen, einerseits während einer Woche am Arbeitsplatz und andererseits mit einer persönlichen Messung, bei der der Proband den Badge 24 Stunden auf sich trug. Darüber hinaus wurde während der medizinischen Untersuchung eine Speichelprobe genommen, um den Nikotin- und Kotiningehalt festzustellen. Ein Fragebogen enthielt zusätzliche Fragen zur Exposition.

Im medizinischen Teil wurde neben Grösse, Gewicht und Blutdruck ein EKG zur Untersuchung der Herzrhythmusvariabilität (HRV), einem quantitativen Marker des autonomen Nervensystems, durchgeführt. Anhand der Pulswellengeschwindigkeit (PWV) wurde die arterielle Steifheit gemessen, die ein Indikator für kardiovaskuläre Risikofaktoren und Arteriosklerose ist. Die respiratorische Gesundheit wurde mit einer Messung des ausgeatmeten Stickstoffoxids (FeNO), einem Entzündungsmarker in der Atemluft, und einem Lungenfunktionstest untersucht. Darüber hinaus wurden beim ersten Termin ein Allergietest und jedes Mal ein ausführliches Interview durchgeführt.

Für die Analyse der Gesundheitsdaten wurden mehrere Modelle entwickelt: Einerseits wurde die Korrelation der Exposition mit den verschiedenen Parametern vor Einführung des Rauchverbots in einer Querschnittsuntersuchung angeschaut. Darüber hinaus wurde die Exposition in einem longitudinalen Modell zu jedem Zeitpunkt mit den jeweiligen Gesundheitsdaten verglichen unter Berücksichtigung der Tatsache, dass mehrere Untersuchungen von einer Person stammen konnten. Als letztes wurde in einem Prä/Post-Modell ein Vergleich der Gesundheitsparameter vor und nach dem Rauchgesetz gemacht ohne Berücksichtigung der genauen Exposition. Die Modelle wurden jeweils für geeignete Kovariablen adjustiert.

Der Verhaltens- und Akzeptanzfragebogen enthielt Fragen zum persönlichen Wissenstand und zur Einstellung zum Rauchverbot, zu Faktoren, die diese beeinflussen sowie zum Rauchstatus und –verhalten. Antworten wurden anhand von angemessenen statistischen Tests verglichen.

Ergebnisse

Die durchschnittliche Rauchexposition in der Interventionsgruppe sank um 2.4 Zigarettenäquivalente/Tag nach dem Rauchverbot während die Veränderung in der exponierten Kontrollgruppe signifikant kleiner war.

In einer Querschnittsuntersuchung der Baseline Daten wurde festgestellt, dass die mittleren Lungenfunktionswerte der exponierten Gastgewerbemitarbeiter unter der schweizerischen Durchschnittsbevölkerung lag. Die FeNO Werte waren direkt mit der Exposition assoziiert, wobei eine Erhöhung der Exposition eine Verminderung des Entzündungsmarkers bedeutete.

Im longitudinalen Modell, das die Exposition mit den Gesundheitsmassen verglich, korrelierten mehrere HRV Parameter signifikant mit der Exposition. Die Abnahme um ein Zigarettenäquivalent/Tag war mit einer Erhöhung der RMSSD (Quadratwurzel der Summe der quadrierten Differenzen zwischen benachbarten RR-Intervallen), der SDNN (Standardabweichung der RR-Intervalle), der HF- (High Frequency) und der TP- (Total Power) Komponente verbunden, sowie mit einer Abnahme der Pulswellengeschwindigkeit. Diese Assoziationen entsprachen der ursprünglichen Hypothese, die eine bessere Gesundheit mit niedrigerer Exposition voraussagte.

Im Prä/Post-Modell ohne Berücksichtigung der genauen Exposition wurde bei mehreren Parametern eine signifikant unterschiedliche Entwicklung in der Interventionsgruppe im Vergleich zur Kontrollgruppe gestellt. So stiegen SDNN, RMSSD, HF, und TP in der Interventionsgruppe alle an, während sie in der Kontrollgruppe absanken. Der HF/LF (High Frequency/Low Frequency) Quotient verhielt sich umgekehrt, ein Effekt, der auch den Erwartungen entsprach. FeNO sank in der Interventionsgruppe ab, während sich die Kontrollgruppe mit einem kleinen Anstieg signifikant anders verhielt. Bei den Lungenfunktionsparametern konnte keine Veränderung beobachtet werden.

Die Akzeptanz des Rauchverbots war von Anfang an höher bei den Nichtrauchern als bei den Rauchern. Sie erhöhte sich jedoch in beiden Gruppen im Kanton Basel Land, in dem ein umfassendes Rauchverbot eingeführt wurde, während das in den andern beiden Kantonen, die Ausnahmen zuliessen, nicht der Fall war.

Diskussion

In dieser Studie wurden klare Anzeichen einer verbesserten kardiovaskulären Gesundheit der nichtrauchenden Gastronomiemitarbeiter nach Einführung des Rauchverbots gefunden. Die Risikofaktoren für einen Herzinfarkt oder eine Arteriosklerose hatten sich in der Interventionsgruppe signifikant vermindert. Bei der Lungenfunktion konnte keine Veränderung festgestellt werden während beim FeNO zwar eine Abnahme beobachtet wurde, die jedoch nicht als klinisch relevant betrachtet werden kann. Somit scheinen die Herzrhythmusvariabilität und die Pulswellengeschwindigkeit die sensitivsten Marker zu sein, während die Lungenfunktion womöglich entweder länger braucht, um sich zu erholen oder dauerhaft geschädigt bleibt. FeNO wird von sehr vielen Faktoren beeinflusst und sollte daher noch weiter erforscht werden.

All diese Resultate sprechen für ein umfassendes Rauchverbot ohne Ausnahmen. Die erhöhte Akzeptanz dieser Form der Regelung, die wir fanden, unterstützt diese Empfehlung weiter.

Trotzdem wurde eine Initiative der Lungenliga, die genau diese Vereinheitlichung des Gesetzes verlangte, im September 2012 abgelehnt. Während des lebhaften Abstimmungskampfes wurden auch erste Studienresultate publiziert. Der Misserfolg der Kampagne wirft die Frage auf, ob Gesundheit als politisches Argument attraktiv ist, wenn dabei eine Einschränkung der persönlichen

Entscheidungsfreiheit droht. Ausserdem muss die Rolle der Tabakindustrie, die in der Schweiz als wichtiger Arbeitgeber und Steuerzahler eine übermächtige Stellung hat, näher betrachtet und ins Bewusstsein der Bürger gerückt werden. Die vermeintliche persönliche Freiheit der Schweizer über ihr Rauchverhalten zu entscheiden scheint doch eher eine Selbsttäuschung zu sein, herbeigeführt mittels einer verdeckten Gehirnwäsche durch die wohl manipulativste Industrie der Welt.

"…with a general lengthening of the expectation of life we really need something for people to die of…"

Report for Tobacco Advisory Council, 1978

1 INTRODUCTION

This thesis deals with the effects of a smoking ban on exposure to second hand smoke (SHS) and cardio-respiratory health of non-smoking hospitality workers as well as behaviour and acceptance of hospitality workers regarding smoking bans in Switzerland.

1.1 Tobacco from a public health perspective

Tobacco consumption, including active and passive cigarette smoking, was one of the three leading risk factors for the global burden of disease in 1990 and remained so in 2010 despite considerable shifts among other risk factors (1). In men it continues to be the number one risk factor while climbing from rank five to four in women. Tobacco takes up this position in large parts of the world making it a truly global phenomenon.

1.1.1 Active smoking

Around one billion men and 250 million women smoke worldwide. In developed countries this corresponds to a smoking prevalence of 35% in men and 22% in women. In developing countries half of all men smoke compared to 9% of women who more often rather chew tobacco. The epidemic is slowly shifting to the developing world as the tobacco industry is reaching out to newer markets (2). Numbers are continuing to grow in these regions of the world while they are slowly decreasing in the more industrialized parts.

Apart from gender, education and socio-economic status are major influencing factors on smoking status. Those least educated and people below the poverty levels, two groups that often overlap, show the highest smoking prevalence (3).

In Switzerland 27% of the population smoked in 2010, 6% more men than women (4). Of these, 19% were daily smokers, but numbers have been declining since the year 2000. On average, less Swiss men and more Swiss women smoke in comparison to international figures.

30-50% of all smokers die prematurely, half of them in middle life between the age of 35 and 69. This means that an average smoking death reduces life by 20 years.
Lung cancer is the second most common type of cancer in both men and women and the most frequent cause of cancer-related death. This makes tobacco the single greatest preventable cause of death due to cancer. However, smoking also damages the body in many other ways (Figure 1-1) (5, 6). It promotes chronic diseases such as heart disease, pneumonia, hardening of the arteries, chronic lung disease and asthma (7). A large number of non-communicable diseases moved upwards in the ranking of global disability-adjusted life years (DALYs) between 1990 and 2010. DALYs represent the sum of years of life lost (YLL) and years lived with Disability (YLD), adjusted for the severity of disability. Smoking remains one of the major behavioural risk factors for many of these (8). Cardiovascular and circulatory diseases are the largest contributor to DALYS relating to tobacco (41%).
The risk of falling ill as a result of tobacco consumption is strongly influenced by the amount of cigarettes smoked as well as the age at which the habit is taken up. What

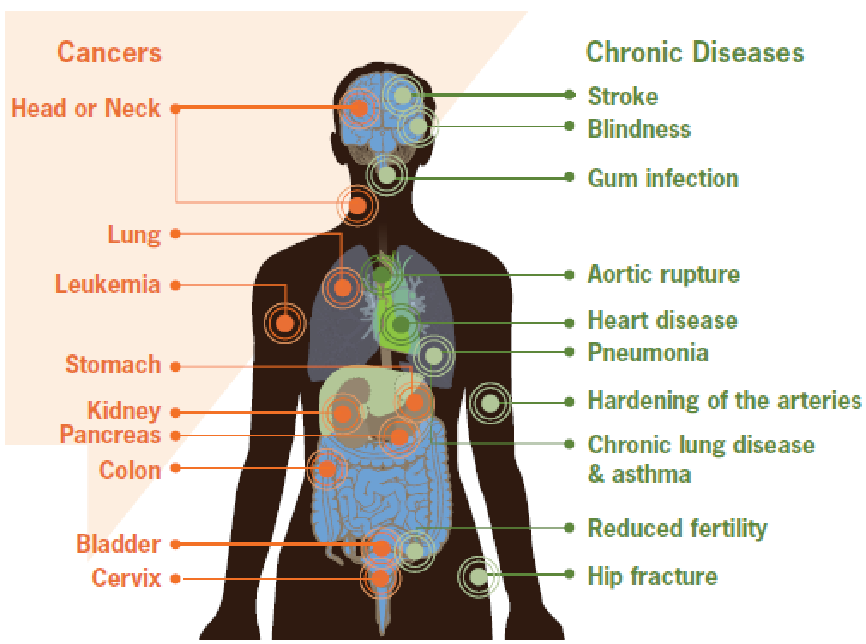

Figure 1-1 Body parts affected by smoking (9)

makes it a habit is addiction, another devastating cause and consequence of smoking. 50-60% of all regular smokers develop a dependency on nicotine, a tobacco specific alkaloid (10). Though not a direct cause of tobacco-related diseases, nicotine is the major psychoactive component of smoke. It leads to an increase in heart rate and blood pressure and directly affects the brain within seconds. Cessation of regular supply can lead to withdrawal symptoms such as anxiety, aggression, lack of concentration, depression, unrest, sleep disorders and increased appetite (11).

The relationship between active smoking and a wide array of detrimental health effects are largely indisputable but these harms are also allegedly self-inflicted. The topic of SHS and consequential involuntary tobacco smoking harming casual bystanders brought the debate to a whole new level (12).

1.1.2 Second hand smoke

Second hand smoke (SHS), also often referred to as Environmental Tobacco Smoke (ETS), is made up of 15% mainstream smoke which the smoker inhales and exhales and 85% sidestream smoke which comes off the smouldering end of the cigarette (13). The chemical constituents of these two types are similar, but undiluted sidestream smoke is considered more dangerous as components are incompletely burned due to lower temperature. The concentration of toxins in sidestream smoke is up to 10 times higher than in mainstream smoke and toxicity increases the longer the smoke lingers in the air (14).

Broadly speaking, cigarette smoke aerosol consists of CO, other vapour-phase components, particulate matter (tar) and nicotine (15). It is a complex and dynamic mixture containing more than 4000 chemicals, out of which around 200 are toxic and at least 60 are carcinogenic (15, 16). The hazardousness further increases when components interact. Especially polycyclic aromatic hydrocarbons lead to tumours in the respiratory organs that are in direct contact with tobacco smoke (17). Furthermore aromatic amines and tobacco specific N-Nitrosamines as well as other chemicals are carcinogenic. Other noteworthy components are hydrogen cyanide and Polonium 210, a radioactive metal. SHS has been classified as a Group 1 (human) carcinogen by the International Agency for Research on Cancer (IARC) (15). According to the Surgeon General's Report from 2006 there is no risk-free exposure level to SHS (18).

The amount of smoke created through smoking depends on the quantity of tobacco being burnt. A large cigar may produce as much smoke as an entire packet of cigarettes (19). Despite filtration and ventilation, SHS can be detected in the air of any room in a building if smoking is allowed in a part of the building(20).

1.1.3 Passive smoking

Passive smoking is the inhalation of SHS by persons other than the one actively smoking, most prominently in closed spaces, such as homes, workplaces or cars. In 1990, DALYs attributable to passive smoking worldwide corresponded to approximately 38 million, in 2010 this number had decreased to 20 million (1). Nevertheless, 600 000 people still die from exposure to SHS each year (21).

The most vulnerable groups are women (47% of all attributable deaths), and children (28%) (22). Children are often exposed to SHS at home by smoking parents, a trend that is significantly heightened in socioeconomically disadvantaged households (23). These children may suffer from acute otitis media, bronchitis and pneumonia (16). Child mortality related to SHS exposure is often caused by infections of the lower respiratory tract or asthma. A non-smoking mother exposed to SHS during pregnancy increases the risk of stillbirth, low birth weight and congenital anomalies while postnatal exposure to SHS increases the risk of sudden infant death syndrome (SIDS) (24-26).

The main causes of death from passive smoking in adults are ischaemic heart disease, asthma and lung cancer. If exposed on a regular basis these risks can be elevated by 20-30% (16).

Passive smoking is involuntary and health damages affect the most vulnerable groups. The tobacco industry soon identified the issue of passive smoking as more threatening to business than any former regulation or prohibition had been. Smoking was in danger of losing its social acceptability and potential economic damages were to be expected (27).

1.1.4 Cardiovascular and respiratory health

The list of illnesses related to tobacco consumption has continuously been expanded. The cardiovascular as well as the respiratory system are among the most susceptible to the effects of air pollutants such as SHS.

Cardio-respiratory health factors were central to this thesis. Below the markers we examined are introduced.

Respiratory diseases account for 18% of all tobacco related deaths (28). Studies indicate a linear dose-response relationship between both active and passive smoking and lung cancer (29). A large number of pack years[1] correspondingly leads to an increase in lung cancer risk.

Spirometry

Spirometry (the measuring of breath) is the most common pulmonary function test. It measures lung function, specifically the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled (30). In common practice it may be used to diagnose asthma and obstructive or restrictive lung diseases (31).

Fractional exhaled nitric oxide

Fractional exhaled nitric oxide (FeNO) is an inflammatory marker mainly originating in the respiratory epithelium (32). Active smoking has been shown to reduce FeNO levels in exhaled air but knowledge on effects of passive smoking as well as reliable reference values are scarce (33, 34), therefore our research regarding cessation of SHS exposure and FeNO was more explorative than with the other outcomes.

Cardiovascular health examinations suggest a different association pattern to smoking than respiratory studies. The risk of myocardial infarction and coronary heart diseases increases steeply at low doses of SHS exposure or by actively smoking 1-2 cigarettes per day (Figure 1-2). This is in contrast to other substances such as reduced high density lipoprotein cholesterol or increases in

[1]Quantification of cigarette smoking: Number of pack years = (packs smoked per day) × (years as a smoker)

carboxyhaemoglobin concentrations that show a more linear dose-response relationship with heart disease (35).

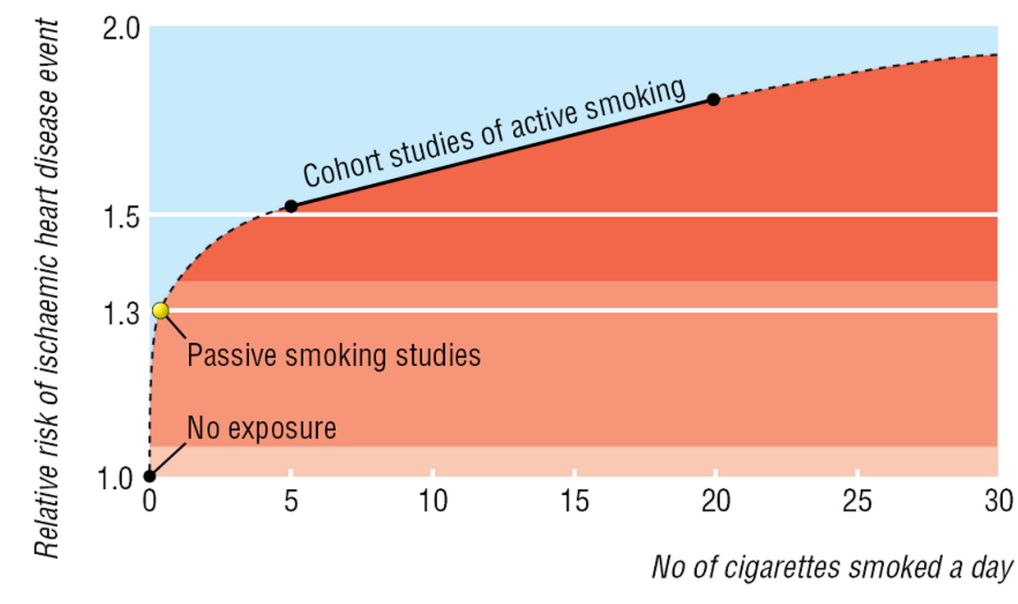

Figure 1-2 Non-linear dose-response association between exposure to tobacco smoke toxins and ischaemic heart disease (36).

Heart Rate Variability

The electrocardiogram (ECG) is a standard diagnostic tool in cardiology. It is painless, non-invasive and reproducible under standardized conditions (37). It records the electrical activity of the heart and sheds light on the status of the Autonomic Nervous System (ANS). When measuring heart rate variability (HRV), the temporal pattern between heart beats (RR- or NN-interval) is the focus (Figure 1-3).

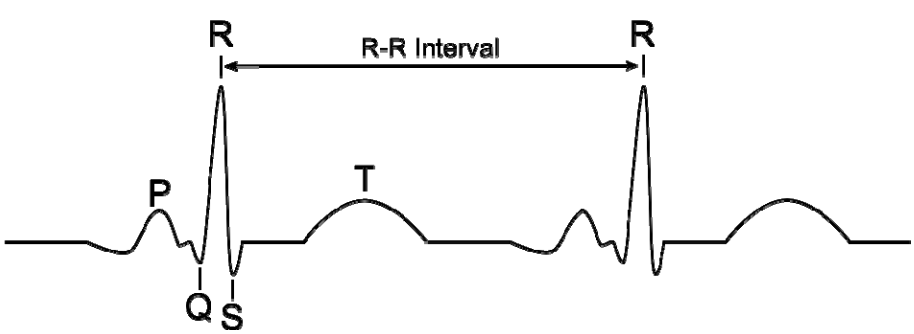

Figure 1-3 Peaks and RR interval of an ECG signal (38)

Even when at rest, spontaneous variation is desirable indicating the ability of the heart to adapt to changes in stress (Figure 1-4). In smokers, this ability to adapt is restricted, shown in decreased variation (39). Decreased HRV is associated with an elevated risk for cardiovascular disease (40, 41)and overall mortality (42, 43).

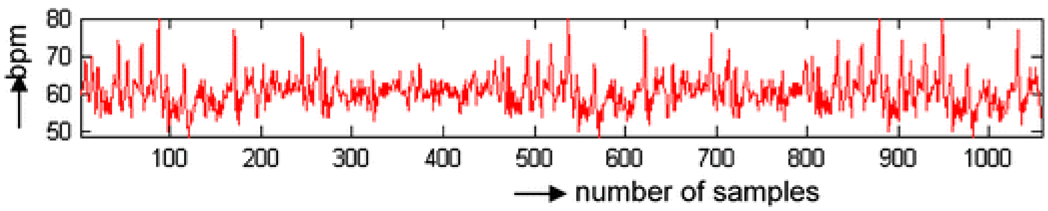

Figure 1-4 Heart Rate Variability of a normal subject (39)

One simple statistical parameter to analyse the temporal domain of HRV is the Standard Deviation of N-N Intervals (SDNN). Apart from the temporal domain, there is a frequency domain which can give more detailed information on the exact composition of frequency shares that make up the HRV. Parameters include High Frequency (HF) or Low Frequency (LF).

Arterial Stiffness

Measuring pulse wave velocity (PWV) is a non-invasive method for assessing arterial stiffness. It involves measurement of two quantities: transit time of the arterial pulse along the analysed arterial segment and distance on the skin between both recording sites (44). The pulse wave that is generated by the left ventricle is transferred along the vascular wall with a velocity depending on the vascular elasticity (Figure 1-5). PWV inversely correlates with arterial elasticity: a high PWV means that arterial stiffness is high and elasticity is low. PWV is an independent predictor of adverse cardiovascular events such as arteriosclerosis (45).

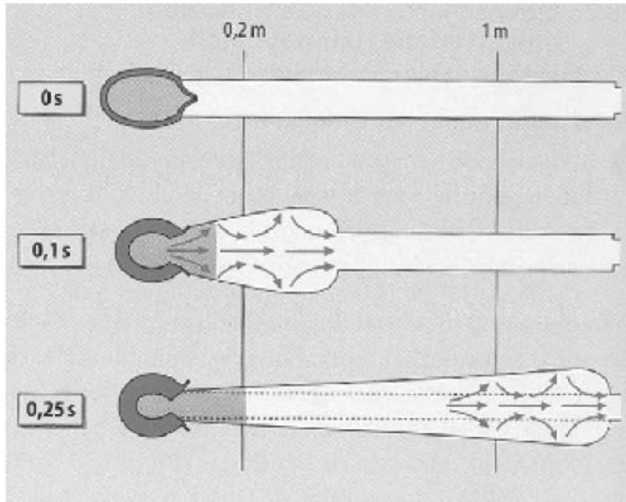

Figure 1-5 Physiological principle of pulse wave velocity

1.2 Tobacco from a historical and political perspective

The 20th century belonged to the cigarette. It experienced several decades of rising popularity before becoming the object of an intense debate between several parties, each gaining the upper hand at different stages. The increasing number of smoking bans worldwide testifies to the growing success of the anti-tobacco movement. But along the way it had to experience many set-backs.

1.2.1 The rise and fall of the cigarette

When tobacco was first imported to Europe in the 16th century, foreseeing King James I of England declared that smoking was “a custom loathsome to the eye, hateful to the nose, harmful to the brain, dangerous to the lungs…” (46). Nevertheless this plant came into vogue during the centuries to come, first mainly in the form of snuff and later as a cigar. Following the 1883 invention of the cigarette machine, the first modern cigarette was produced in the USA by RJ Reynolds in 1913 just in time for the First World War. Cigarettes were freely distributed to the troops and at times even used as commodity money (47). The Second World War generated another surge in popularity; in those years tobacco companies still claimed that smoking was beneficial to health and families actually believed they were doing soldiers a favour by supplying them with cigarettes. Today, cigarettes account for 96% of the value of all tobacco products sold globally (48).

At the beginning of the 20th century lung cancer was virtually non-existent, but rates suddenly started to rise steeply in the 1940s, due to the long lag phase of 20-30 years. In 1939 Ochsner and DeBakey first suspected the link between smoking and lung cancer (49). In 1950 tobacco advertising on television began and often used celebrities to appeal to youths. In the same year, A. Bradford Hill released a preliminary report proving that lung cancer was caused by smoking (50), a publication that soon reached legendary status. It denoted the start of a long term cohort study on mortality related to smoking habits of British doctors, a study that was continued until 2001 and would ultimately earn the authors knighthood. The main findings were that persons who give up smoking before the age of 30 do not die prematurely while 10 years of life are lost if smoking is continued until 70 (51-55).

The 1950s therefore represented the starting point of a public health battle that soon reached global status and continues to be fought to the present day. It involves a powerful industry, politicians, health advocates and innumerable interest groups. When the Surgeon General's Report stated in 1964 that smoking causes lung cancer in men this had to be communicated in a secured press conference (56). Smoking prevalence dropped by 20% after this, but only transiently, and finally peaked in the US in 1965 (57).

In response to criticism, the industry developed a low-tar, "light" and a low-nicotine cigarette which were promoted as less dangerous and less addictive (58). It organized a worldwide network of scientific consultants to mislead the media, the public and healthcare advocates (59). Scientific results were downplayed, questioned and denied (60-63). These measures helped buy the industry time, and significantly delayed the introduction of smoking bans. However, in the 1970s the first cigarette advertising bans on TV and radio were implemented (64).

The discussion on smoking bans in public places emerged when the dangers of involuntary tobacco smoking came into play. The first reports on adverse health effects of passive smoking were published in 1981 by the Japanese scientist Hirayama who observed that non-smoking wives of heavy smokers had a higher risk of lung cancer (65). By 1986 it was widely accepted among scientific circles that SHS indeed also caused lung cancer. Even before this the World Health Assembly (WHA), the decision-making body of the World Health Organisation (WHO), released a report expressing for the first time the need for a framework for effective tobacco control. Finally, recognizing the trans-national character of the industry and the need for a global response to the growing worldwide tobacco epidemic, in 1997 the WHO initiated its first international treaty, the Framework Convention on Tobacco Control (FCTC).

1.2.2 The WHO Framework Convention on Tobacco Control (FCTC)

The FCTC was the first treaty to be negotiated by the WHO. It is an evidence-based treaty resting upon the WHO constitution from 1946 that stated the objective of the WHO is the attainment of the highest possible level of health by all peoples (66). Negotiations on the FCTC started in 1999 and it took four years until the treaty was unanimously approved by the WHO assembly. It came into force in 2005 as one of the globally most recognised treaties with 168 signature states. To date it has been ratified by 176 states.

The most important obligations of the treaty are the following (67):

- product declarations and warnings on all tobacco products;
- restrictions in tobacco marketing and sponsoring;
- control of cigarette smuggling, of illegal fabrication and counterfeiting of tobacco products;
- prohibition of selling tobacco products to minors.

Article 8 deals with protection from exposure to SHS: treaty members are obliged to undertake measures to protect people from SHS at the workplace, in closed spaces and in public transportation, facilities and places.

Additionally price and tax measures are to be taken to reduce the demand for tobacco (68). The FCTC is supported by the Department of Tobacco Free Initiative (TFI), a project by the WHO designated to reduce the global burden of disease and death caused by tobacco. It supports member states in legal, political and financial matters concerning tobacco control and coordinates international activities (69).

Switzerland signed the FCTC in 2004 but, like the USA and seven other countries, never ratified it. This exemplifies the attitude assumed by Switzerland when it comes to tobacco control.

1.2.3 The smoking ban

A smoking ban can either be aimed at public or private areas and may be mandated by law or be voluntarily adopted (59). While the first smoke-free initiatives in the 18th century were designed to reduce fire-risks (70) smoking bans in the 21st century are mainly a consequence of health-related initiatives.

Even before workplace smoking bans became legally binding, many companies voluntarily implemented smoking restrictions. A serious debate on detrimental SHS exposure at the workplace was launched by flight attendants who prior to a ban on aircrafts were the most affected occupational group (59). Today, in many countries, bars and restaurants are primarily regarded as recreational sites, not as work places, and therefore hospitality venues are often excluded from smoking bans. This represents a major issue in the controversies regarding new smoking regulations and exceptions therein (71). Many countries have only implemented partial laws, either leaving room for exceptions or, depending on the political system, covering just parts of a country.

In parallel to this wave of smoking bans, national anti-tobacco movements launched a forceful campaign against tobacco advertising. Adverse health effects and risks of addiction are the main arguments in these advances. Opponents of smoking bans argue that the government interferes with personal lifestyle, hospitality venues may incur economic losses, adequate ventilation sufficiently reduces SHS or that smoking will be moved to private homes where children could be increasingly exposed (71, 72).

In 2004, the Republic of Ireland was the first ever country to implement a comprehensive smoking ban to protect the population from SHS at the workplace, even before ratifying the FCTC (73). Within a few years other European countries such as Italy in 2005 and the UK in 2007 followed (74, 75).

To date 87 nations have enacted some sort of 100% smoke free law, and 59 include both restaurants and bars (76). Though first initiated in industrialized countries, smoking bans have also spread to the developing world. Several Latin-American countries have a comprehensive smoking ban. Asia still lags far behind, but so do many parts of Europe, particularly in the East.

1.3 Tobacco from a Swiss perspective

1.3.1 The smoking ban in Switzerland

Switzerland is a country with a strong democratic and highly devolved federal tradition. A large amount of laws are implemented on a cantonal level. Switzerland is divided into 26 cantons that are separate, largely autonomous administrative zones. The first canton to vote on a smoking ban was Ticino (TI) in 2006: 79% of the population approved a smoke free hospitality sector. Other cantons followed, but many had incorporated exceptions into the law, leaving the possibility open for small venues to remain smoking or for separate smoking rooms. The first national smoking ban, that had been initiated in 2004 and was passed by the federal government on 3 October 2008, was to be implemented on 1 May 2010. The parliament had incorporated some exceptional rules stating that venues smaller than $80m^2$ could continue to run as smoking venues and separate smoking rooms not larger than $^1/_3$ of a venue should also be allowed (77, 78). This quickly led to around 45 organizations dealing with health, prevention, consumer and worker protection as well as youth and parenting to join forces in May 2009, one year before the federal act was implemented. They launched an initiative for a national comprehensive smoking ban. This initiative was submitted in May 2010 shortly after the original ban had come into force. It was rejected on 23 September 2012 as recommended by the government after a lively public debate.

To date Switzerland remains a patchwork of smoking regulations, with sporadic advances by different interest groups to either weaken or tighten the cantonal laws. In Basel Stadt (BS) where parts of the research work for this thesis was performed, there was a vote in November 2011 to downgrade the law to the degree of the national law. This action was supported by the so-called “Fümoar Club” that had been founded on 22 January 2010 in anticipation of the national law. Owners of roughly 185 hospitality venues that continue as smoking venues are members of the club. All guests are required to buy a card for passive membership for 10 CHF per year, non-members are not allowed to visit these venues. A juristic evaluation has declared this type of club as a clear contravention of the law but to date attempts for legal action have been pushed to higher courts delaying any definite action (79). A similar attempt to circumvent the law in another canton was recently declared illegal, and therefore the end of the “Fümoar Club” in BS appears to be solely a question of time.

The most recent initiative on a federal level was submitted for preliminary examination by the “Swiss committee against passive smoking” from Geneva to the federal chancellery in May 2012. It demands “protection of health from passive smoking – for an effective and non-discriminatory protection along the lines of the WHO”, expanding demand to include, for the first time, regulation of private settings. The 18 month long signature collection for the initiative to be approved for a national vote will end on 19 December 2013 (80).

1.3.2 The economic significance of tobacco for Switzerland

Switzerland is of particular interest to the tobacco industry. International tobacco companies such as Japan Tobacco (JT) and British American Tobacco (BAT) have their biggest branch office outside of the US in Switzerland and Philipp Morris has its global headquarters in Lausanne. All three companies hold large cigarette manufacturing factories in this country and are therefore important employers and tax payers.

An average package of cigarettes currently costs 7.90 CHF, adjusted for purchasing power this is among the cheapest in high income countries (81). 54% of the revenues are taxes that are entirely used for the Old-Age and Survivors Insurance (AHV) and the Disability Insurance (IV). The Swiss government earned 2.2 Billion CHF from tobacco sales taxes in 2011. 0.3% of the revenues from cigarette sales are used in support of local tobacco growers, the same amount that goes into the tobacco prevention fund (TPF) (82). The fund was set up to finance prevention strategies, keep people from taking up tobacco smoking, support quitting and protect the population from SHS (83).

Tobacco consumption costs the Swiss economy around 10 billion CHF/year. Medical treatment accounts for 1.2 billion of these, while costs related to working hours lost to illness and invalidity contribute 3.8 billion (84). The remaining 5 billion are an estimate for loss of quality of life. Direct health costs from SHS exposure in public places have been estimated at 330 m CHF/year (85).

In Switzerland smoking is the leading preventable cause of death (86), which provides the main motivation for this research as described in the aims below.

2 AIMS AND OBJECTIVES OF THIS THESIS

> "We will continue to use all necessary resources… and where necessary litigation, to actively challenge unreasonable regulatory proposals."
>
> Louis Camilleri,
> Chairperson and CEO,
> Philip Morris
> International, 2010

2.1 Research gaps

Despite the large number of studies that have been performed in numerous countries surrounding the implementation of a public smoking ban, several issues regarding exposure assessment and health effects remain unresolved. Reliable methods to assess personal SHS exposure and the most appropriate markers to observe the influence of SHS on health risks are still to be evaluated. Moreover, most former smoking ban study designs did not permit the inclusion of a control group as the bans were usually introduced in the entire study region. The COSIBAR (Cohort Study on Smoking Interventions in Bars and Restaurants) aimed to illuminate many of these open questions by applying several methods to measure SHS exposure, examining a variety of health outcomes and by including a control group.

Exposure to second hand smoke

Previous studies usually used a single measure to determine exposure. This was often a proxy for SHS such as $PM_{2.5}$ or even more commonly self-reported estimations. The COSIBAR study compared and evaluated several objective exposure measurement methods in parallel, all of them specific to tobacco. Exposure results are discussed in Article 1, Section 4 of this thesis.

Cardiovascular health outcomes

Although SHS is a widely recognized risk factor for heart disease, there are still ample knowledge gaps on cardiovascular effects of a smoking ban, in particular with respect to long term exposure. This study examined cardiovascular health by means of two methods assessing HRV, a quantitative marker of autonomic activity of the nervous system, and PWV, a marker of arterial stiffness. Results on these measurements are addressed in Article 2 in Section 5 of this thesis.

Respiratory health outcomes

Fractioned Exhaled Nitric Oxide (FeNO), an inflammatory marker of the lungs, has not been investigated in most smoking ban studies. Previous publications on FeNO in smokers and asthmatics suggested this could be a further interesting though complex marker in assessing airway inflammation in connection with SHS exposure. Results on this topic are summarized in Article 3 in Section 6 of this thesis.

Research on lung function developments in non-smokers after a smoking ban has delivered contradictory results as to which parameters undergo a change and how long it takes for potential improvements to come about. We included spirometry to further clarify these issues. To complement these findings we also asked several questions on respiratory symptoms in the interview. Corresponding results are to be found in Article 3 in Section 6 of this thesis.

Behaviour towards and acceptance of the smoking ban

It is still uncertain how different levels of smoking regulations are accepted by hospitality workers and if rules are complied with. Results from other countries examining behaviour and acceptance after a complete smoking ban cannot be directly applied to the heterogeneous situation in Switzerland with different regulations in a small geographic area. In the COSIBAR study a questionnaire assessing these issues was distributed to smoking and non-smoking hospitality workers. The analyses and interpretation are summarized in Article 4 in Section 7 of this thesis.

2.2 Questions and objectives

The overall aim of this study was to compare changes in SHS exposure and cardio-respiratory health in non-smoking hospitality workers that experience a smoking ban at their workplace to a control group that did not undergo any changes in exposure. In addition, potential changes in behaviour and acceptance in smoking and non-smoking hospitality workers were assessed.

On the basis of our results the following methodological questions and wider policy relevant issues are addressed in the discussion in Section 9 of this thesis:

1) Our findings in context: How do they fit in with other studies?
2) Methodological Issues: What are the strengths and limitations?
3) Hospitality workers: Is this a suitable study population?
4) From research to policy: How could our results impact policy-making?
5) Future tobacco research: What are key issues and goals?

3 STUDY SETTING AND METHODS

> "A few weeks before the ban came into force in Ireland, Dublin banker Jimmy Fogarty asked the barman at his local pub: 'What are you going to do when the ban comes in?' 'Breathe', the barman replied."
>
> Bulletin of the World Health Organization, Ireland, 2006

3.1 Study Design

COSIBAR (Cohort Study on Smoking Interventions in Bars and Restaurants) is a prospective cohort study that used the implementation of a nationwide smoking ban in May 2010 as an intervention to create a quasi-experimental research setting. Several cantons – administrative zones in Switzerland – had already issued a smoking ban before the federal law on second hand smoke (Bundesgesetz zum Schutz vor Passivrauchen, SR 818.31) was implemented but these regulations varied in strictness (Figure 3-1). The federal law prohibited smoking in closed spaces that are either public or serve as a workplace. Hospitality venues below 80 m^2 in size were still allowed to be run as smoking venues if adequately ventilated (77). An amendment added that smoking rooms that do not exceed $^1/_3$ of the entire venue should also remain optional (78). Cantons continued to be free to implement more stringent laws.

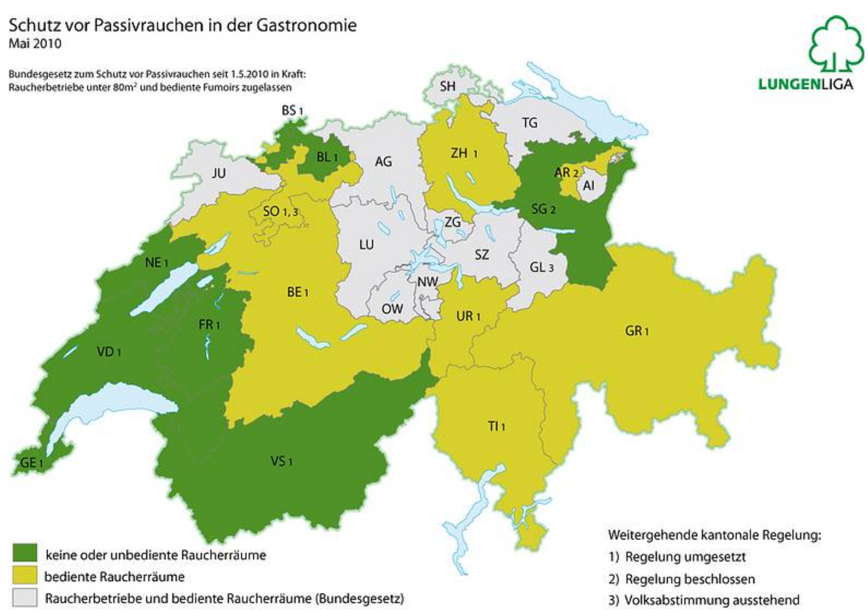

Figure 3-1 Heterogeneity in smoking legislation across different cantons in Switzerland

COSIBAR was to be carried out in three cantons that did not have any ban in place before 1 May 2010: Basel City (BS), Basel County (BL) and Zurich (ZH).
While the population in BS and BL had voted for the most stringent version of the regulation in Switzerland, only allowing unattended smoking rooms, ZH added one amendment to the basic national law by additionally prohibiting small smoking venues below $80m^2$ but permitting owners to arrange a smoking room according to the national law. BS already implemented the new law on 1 April 2010, so there were no further changes in this canton on 1 May 2010 and baseline measurements of the study needed to be finalized one month earlier.
Due to these heterogeneous regulations the COSIBAR study had the unique opportunity of comparing a group of hospitality workers experiencing a strict new law to a group that remained exposed to SHS at different degrees after 1 May 2010. Prior to implementation of the ban we performed baseline measurements of SHS in all complying venues and invited eligible participants to the medical examination.

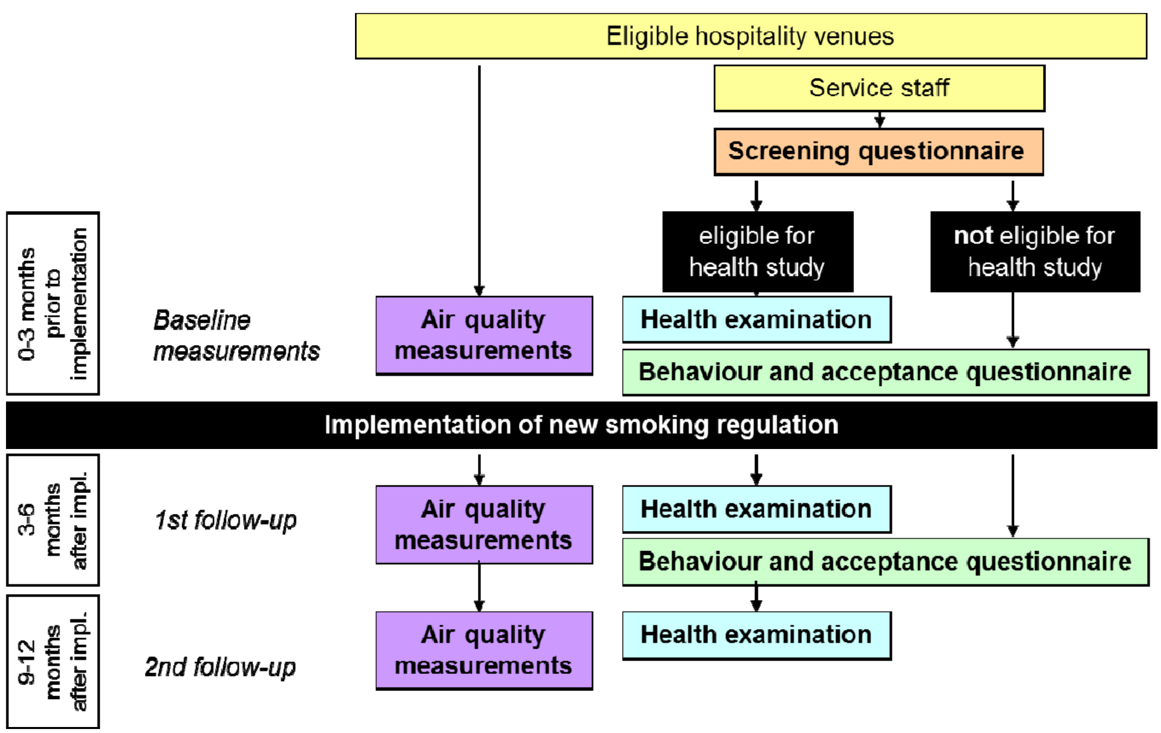

Figure 3-2 Overview of the study design

The behaviour and acceptance questionnaire was sent to all hospitality workers that gave us their address irrespective of smoking status.

Participants of the medical examination were invited to two follow-up examinations, six and twelve months after the ban. Exposure data was collected collaterally each time. At baseline the number of venues far exceeded participants. After the ban a convenience sample was measured again, including all that were participants' workplaces. The behaviour and acceptance survey was repeated after six months (Figure 3-2).

3.2 Recruitment

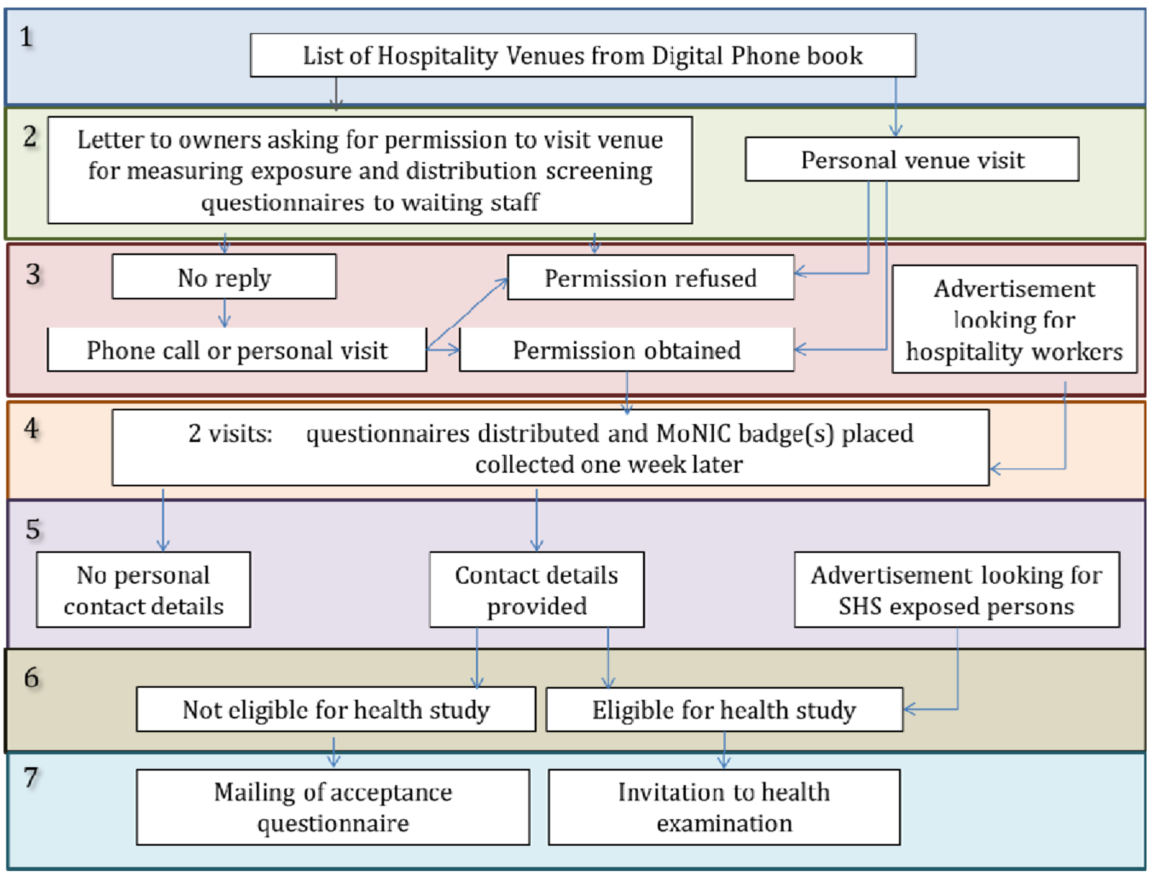

Figure 3-3 Recruitment procedure

After ethical clearance had been received from the EKBB in December 2009, recruitment started in January 2010 according to the scheme in Figure 3-3. A comprehensive list of hospitality venues was drawn from the digital Swiss phonebook 2009 ① and invitation letters containing information on the study and a form to schedule a visit were sent to all. Non-responders were followed-up by phone and direct personal visits ②. Whenever we got permission from the owner of a smoking venue ③, we deposited MoNIC badges for SHS measurements and distributed screening questionnaires to the staff. After one week we went back to pick up both ④. Eligible study participants were invited to a health examination, which was carried out in one of the two study centres in Basel and Zurich ⑦. Hospitality workers that were not eligible for the health study received the behaviour and acceptance questionnaire by post.

Due to the poor response rate several amendments were made to the procedure during the whole recruitment period:

- Control group members were further recruited after implementation of the new law.
- We visited hospitality venues directly without prior arrangement, emphasized the possibility of expressing their opinion in the acceptance questionnaire, we shortened and adapted the screening questionnaire, added a support letter from the cantonal physician and also directly enclosed the acceptance questionnaire in the mailing.
- We placed an advertisement in the 20 minutes newspaper in ZH, the most popular free newspaper, and in the gastronomy paper "Expresso" and placed a link on the website of the Swiss gastronomy association.
- We hired someone solely to recruit more participants and extended the control group to non-exposed hospitality workers that had always worked in a smoke-free environment.
- We also looked for non-hospitality workers exposed to SHS on a regular basis by means of an online advertisement to further expand the exposed control group ⑤.

3.3 Study Sample

At baseline, 225 badges were placed in 193 hospitality venues consisting of 126 restaurants, 31 cafés and 36 bars. At follow-up 1, we measured 51 venues with 52 badges and at follow-up 2, 42 badges were placed in 36 venues.

Eligibility criteria for the medical examination were being between 18 and 65 years of age, working at least half-time, having worked for at least one year in the hospitality sector and having been a non-smoker for at least 5 years. Persons, who intended to leave the job within the next three months or were pregnant, were excluded.

The medical survey was conducted with 92 participants at baseline, 57 women and 35 men with an average age of 40.3 (95%-CI: 37.6 to 43.0). 56 came back at follow-up 1 (60.9%) and 48 at follow-up 2 (52.2%). 44 persons attended all three examinations (47.8%). Participants were divided into four groups: a) the Intervention group, hospitality workers that experienced a change in exposure, b) Control group I, hospitality workers that remained exposed to SHS after the ban, c) Control group II, hospitality workers that had always worked in a smoke-free environment and d) Control group III, that consisted of people that were SHS exposed on a regular basis without being employed in the hospitality sector (Figure 3-4). Control groups I and III were merged for analysis (referred to as exposed control group).

The behaviour and acceptance survey that included smoking and non-smoking hospitality workers had 109 participants at baseline and 83 at follow-up (76.1%). 71 persons filled in the questionnaire twice. Non-smoking respondents were mainly participants from the medical examination.

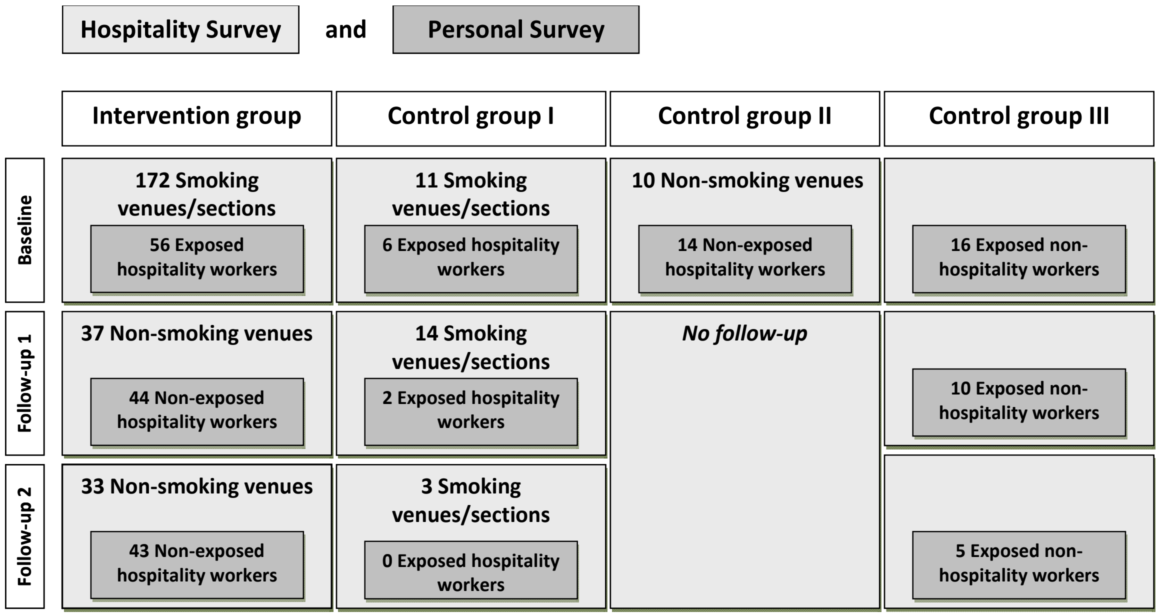

Figure 3-4 Study sample: Hospitality venues and participants of the medical examination

3.4 Exposure Measurements

In this study, exposure to SHS was measured using three different methods resulting in five parameters:

- The newly developed MoNIC (Monitor of nicotine) badge, a passive sampler, is a glass fibre filter that is washed with distilled water, methanol and CH_2Cl_2 (Dichloromethane) and impregnated with 5mg sodium bisulphate per filter (87). It is transported in an air-tight plastic case between the lab and measurement sites. It may be placed in a room for up to a week or can be worn as a brooch near the respiratory organs for a personal measurement. The amount of nicotine on the badge is assessed by gas chromatography and used to calculate the number of passively smoked cigarettes per day (CE/d) assuming a nicotine content of 0.2 mg/cigarette and an average ventilation rate of 10 L/min (88).

  Participants were asked to wear badges on themselves (Figure 3-5) for 24 hours for a personal measurement and to fill in a badge protocol providing details on the exact times and locations of measurement.

Figure 3-5 The MoNIC badge and its application

1-2 badges, depending on the number of smoking and non-smoking sections, were placed in the hospitality venues for one week, often near the bar where waiting personnel spend much of their working time. We calculated a time-weighted average for workplace exposure taking into account work load and regular work time. The 24h badge value was multiplied by 1.75 considering that nicotine levels decrease when the venue is closed. This factor was estimated from a previous study of continuous $PM_{2.5}$ measurements in smoking environments (20). For a full-time employee the obtained concentration was divided by three to calculate average CE/d assuming an eight hour shift/day. The value for part-time employees was derived by further dividing according to the workload. For non-hospitality workers average SHS exposure was obtained from a personal badge that participants wore on themselves on a typical day.

- A saliva sample was taken at each medical examination to determine current nicotine and cotinine concentration.
- A questionnaire provided self-reported exposure information.

3.5 Health Examinations

Health examinations were performed in one of our study centres in either Zurich or Basel. The following outcomes were recorded:

- Height and weight
- Hip and waist circumference

- Heart Rate Variability (HRV), a quantitative marker of autonomic activity of the nervous system that is associated with cardiovascular morbidity and mortality
- Pulse wave velocity (PWV), a measure of arterial stiffness which is an important indicator of cardiovascular risk factors and atherosclerosis
- Blood pressure
- A skin prick test on the forearm to diagnose allergies
- Fractional exhaled nitric oxide (FeNO), a marker of inflammation in the lungs
- Spirometry to measure lung function
- An extensive questionnaire including information on respiratory symptoms, cardio-vascular medical history, medicine intake, allergy symptoms, smoking and alcohol consumption, quality of life, sleeping habits, physical activity, living conditions and noise exposure. This was partly conducted as a computer based interview and partly on paper.

3.6 Behaviour and Acceptance Survey

The written questionnaire contained 83 questions about current smoking regulations at the workplace and their compliance. It covered cognitive acceptance issues such as personal relevance and knowledge about the law, social factors (perception of non-smoking as a social norm and perception of relevant peers) and proactive acceptance and perceived annoyance at the workplace and as a guest. Smoking status and behaviour (smokers only) were assessed according to the WHO definition (89).

3.7 Data Analysis

We developed statistical association models to answer the different research questions. All analyses were adjusted for the appropriate covariates that were determined for each outcome. Further details and results can be found in the corresponding articles in sections 4 to 7 of this thesis.

Is cardio-respiratory health in non-smoking hospitality workers affected by long-term SHS exposure before implementation of a smoking ban?

A **cross-sectional analysis** of the outcome data at baseline was done using linear regression with the estimated work place SHS exposure as explanatory variable and adjusting for appropriate covariates. Data from all study participants were used for this model.

Is there a dose-response relationship between SHS exposure and cardio-respiratory health markers before and after a smoking ban?

Covariate-adjusted **exposure response associations** were calculated with a random intercept model using the estimated work place SHS exposure at the time of the health examination as explanatory variable. Data from all study participants were used for this model.

Does cardio-respiratory health improve in an intervention group of non-smoking hospitality workers that experiences a smoking ban in comparison to a control group that remains exposed?

In this model, the two follow-up measures were merged into one post-ban to increase statistical power. Changes in the outcome were compared between the intervention and the control group irrespective of exact exposure. For the intervention group and the exposed control group a pre/post ban exposure variable was derived although in the control group no ban was introduced. For each outcome a **linear mixed effects model with a random subject intercept** was fit including a (study group * pre/post ban) interaction term. Then, crude and adjusted values of the health outcomes prior and after the ban for both groups were calculated. The unexposed control group was excluded in this model.

Do replies in the questionnaires change in the course of the study?

Categorical answers before and after the ban were compared by means of a **Chi²** test. The **Kruskal Wallis** Test was used for numerical data.

These tests were applied for the evaluation of the behaviour and acceptance survey as well as other self-reported outcomes such as respiratory symptoms.

All data were analysed using STATA 10.1 and STATA 12 (StataCorp LP, College Station, TX). Graphs were created with R 3.0.0.

3.8 Ethical Clearance

Ethical approval was obtained from the Ethics committee of both cantons of Basel (EKBB) on 25 November 2009 (Ref. No. EK 317/09). All participants signed an informed consent before every examination.

Methodological issues are discussed in Section 9.2 of this thesis.

4 ARTICLE 1: Impact of a smoking ban in hospitality venues on second hand smoke exposure: a comparison of exposure assessment methods

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ABSTRACT

Background. In May 2010, Switzerland introduced a heterogeneous smoking ban in the hospitality sector. While the law leaves room for exceptions in some cantons, it is comprehensive in others. This longitudinal study uses different measurement methods to examine airborne nicotine levels in hospitality venues and the level of personal exposure of non-smoking hospitality workers before and after implementation of the law.

Methods. Personal exposure to second hand smoke (SHS) was measured by three different methods. We compared a passive sampler called MoNIC (Monitor of NICotine) badge, to salivary cotinine and nicotine concentration as well as questionnaire data. Badges allowed the number of passively smoked cigarettes to be estimated. They were placed at the venues as well as distributed to the participants for personal measurements. To assess personal exposure at work, a time-weighted average of the workplace badge measurements was calculated.

Results. Prior to the ban, smoke-exposed hospitality venues yielded a mean badge value of 4.48 (95%-CI: 3.7 to 5.25; n = 214) cigarette equivalents/day. At follow-up, measurements in venues that had implemented a smoking ban significantly declined to an average of 0.31 (0.17 to 0.45; n = 37) (p = 0.001). Personal badge measurements also significantly decreased from an average of 2.18 (1.31-3.05 n = 53) to 0.25 (0.13-0.36; n = 41) (p = 0.001).Spearman rank correlations between badge exposure measures and salivary measures were small to moderate (0.3 at maximum).

Conclusions. Nicotine levels significantly decreased in all types of hospitality venues after implementation of the smoking ban. In-depth analyses demonstrated that a time-weighted average of the workplace badge measurements represented typical personal SHS exposure at work more reliably than personal exposure measures such as salivary cotinine and nicotine.

BACKGROUND

Banning smoking at workplaces and restaurants is widely recommended as a key intervention for protecting people from exposure to second hand smoke (SHS) (1-3). Although the hospitality sector had been previously excluded from smoking bans, this omission has been amended in many countries over the past 10 years. Today, 28 countries have comprehensive policies banning smoking in all workplaces (4). This trend is in alignment with the recommendations from the World Health Organization's Framework Convention for Tobacco Control (FCTC), stating in Article 8 that all workplaces in closed rooms should be protected from SHS (5). Although Switzerland signed the WHO Convention in 2004, it was never ratified.

There is no comprehensive smoking ban protecting hospitality staff from SHS in Switzerland. In May 2010, a national smoking ban based on a fairly unrestricted regulation which permitted certain exceptions was implemented (6). According to the national law, venues could allow smoking if they were less than $80m^2$ in size or if smoking rooms did not exceed one third of the total venue size. Switzerland is divided into 26 administrative zones called cantons, and each was permitted to implement its own stricter legislation on top of the national law. This has resulted in a patchwork of different laws within a small geographical area.

It has been shown that a partial law can actually lead to an increase in SHS levels in venues that continue to allow smoking (7). In a global cross-sectional study measuring smoking and non-smoking Irish pubs, Connolly et al. found particulate matter less than 2.5 μm in diameter ($PM_{2.5}$) to be 93% lower in smoke-free pubs (8). According to Villarroel et al., $PM_{2.5}$ levels are five times higher in smoking venues than in non-smoking venues (9). Interestingly, several studies found that spatial separation of rooms where smoking is allowed does not prevent exposure to environmental tobacco smoke in nearby non-smoking areas. In 2004, Cains et al. found that spatially separated non-smoking rooms had only marginally reduced particulate matter less than 10 μm in diameter (PM_{10}) and nicotine air levels when compared to a non- smoking area in direct confluence with a smoking area (10). A Swiss study showed that $PM_{2.5}$ in non-smoking rooms of venues that allowed smoking elsewhere in the building was more than double the $PM_{2.5}$ levels of completely smoke-free hospitality venues (11). Several longitudinal studies examined changes in SHS levels before and after introduction of smoking bans. While Semple et al. found an average $PM_{2.5}$ reduction of 86% in Scottish pubs two months after implementation of the law, Lee et al. came up with a slight decrease resulting from a partial law compared to a large decrease from a comprehensive law (12, 13). These effects were reproduced in other places such as Minnesota or Guatemala (14, 15).

The present study is part of COSIBAR (Cohort Study on Smoke-Free Interventions in Bars and Restaurants), a longitudinal quasi-experimental study examining exposure of hospitality workers who were non-smokers, and their health status at three different time points before and after implementation of the new law. There are several established methods to determine personal SHS exposure, all of which have their advantages and disadvantages. The most common and simple way is through a questionnaire (16). Other options include taking biological samples such as urine, saliva, blood or hair. While drawing blood is invasive, both urine and saliva sampling are simple and quick. Commonly the cotinine content is measured, as it is the most specific and sensitive biomarker (17). A hair sample provides cumulative exposure over time, with the last centimetre of hair usually corresponding to the previous month's exposure (18), but this method needs to be further refined (19). In order to determine the SHS exposure within a room, $PM_{2.5}$ levels in air are often used as proxies (11). In this study, SHS exposure of the participants was determined with three different methods. Firstly, by the MoNIC (Monitor of Nicotine) badge, a passive sampling device, secondly, by salivary samples and thirdly, by a personal interview relating to duration of SHS exposure at work and outside of working hours.

The aim of the present study was to analyse the effect of different smoking regulations on SHS exposure in bars, cafés and restaurants and of non-smoking hospitality workers employed therein. In addition, we aimed to evaluate the different methods of SHS exposure assessment and to determine the most accurate proxy for SHS exposure at work.

METHODS

Study design

This is a quasi-experimental, longitudinal study (Figure 4-1) comparing two groups: i) hospitality venues and non-smoking employees for whom smoking was banned as a result of a new smoking regulation (intervention group); ii) hospitality venues and non-smoking employees that did not undergo any change in exposure (control groups). The intervention group of the venue study consisted of hospitality venues where smoking was either partially or completely allowed prior to the introduction of the smoking ban. All compliant venues were included in the study. Participants of the personal study had worked in such a venue for at least one year prior to the ban, and were therefore exposed to SHS. Additional eligibility criteria were being between 18 and 65 years of age, working at least half-time and having been a non-smoker for at least 5 years. After introduction of the smoking ban, the intervention group were no longer exposed to SHS at work. The primary comparison group (Control Group I, Figure 4-1) were employees who were exposed to SHS both before and after the implementation of the smoking ban because of the exceptional rules described above. As hospitality workers who were non-smokers were found to only rarely work in such venues, two additional comparison groups were included in the COSIBAR study. Control Group II consisted of non-smoking hospitality workers who worked in a smoke-free environment at all times, and Control Group III were non-smokers that were regularly exposed to SHS without being employed in the hospitality sector.

In the intervention group, a baseline examination was conducted within the 3 months prior to the introduction of the smoking ban. Subsequently, two follow-up examinations were conducted at 3-6 months and 9-12 months after the smoking ban introduction (Figure 4-1). Study participants of Control Group II were examined only once for a cross-sectional baseline analysis. Control Groups I and III were examined three times, unrelated to the smoking ban. Most of the study participants worked in the cantons of Basel City, Basel County and Zurich. Smoking bans were introduced on 1st April 2010 in Basel City and on 1st May 2010 in Basel County and Zurich.

Recruitment procedure, study population and data collection

A list of all hospitality venues in the cantons of Zurich, Basel City and Basel County was created using the digital Swiss phonebook from 2009. Each venue received a letter with information about the study, including a request to distribute screening questionnaires to staff serving at tables or at the bar (waiting staff) and for air measurements to be performed by the study team. These letters were followed with phone calls and visits two weeks later. For those venues that agreed to participate, an interview with the owner was conducted in order to obtain basic information relating to the current smoking regulations, the venue size, other sources of environmental $PM_{2.5}$ and the number of staff. At least one MoNIC badge was placed in the venue, often near the bar where waiting personnel spend much of their working time (hereafter referred to as “workplace badge”). Where there were separate smoking and non-smoking rooms or sections, one badge was placed in each. After one week, badges were collected and evaluated. For the intervention group, air measurements were performed in 167 hospitality venues that allowed smoking at least partly before implementation of the national smoking ban in May 2010. Follow-up measurements were only conducted in those venues where personal study participants worked. The 26 control group venues were recruited and measured by the same procedures between 2010 and 2011.

For the personal study, screening questionnaires were distributed to the waiting staff, providing information on age, workload (hours/week), number of years worked, smoking status, current health and personal details. Eligible study participants were invited to a health examination, which was carried out in one of two study centres in Basel City and Zurich. Prior to the visit, a MoNIC badge was sent to the study participants which they were asked to attach near their shirt collar for a period of 24 hours and bring to the study centre (hereafter referred to as “personal badge”). A protocol stating the exact measurement time and location accompanied each badge. During the visit at the study centre, saliva was collected for nicotine and cotinine analyses. A questionnaire, part of which was conducted as a face-to-face interview, was completed relating to smoking behaviour and SHS exposure over the previous 12 months at work and outside of work. The participants were asked at the baseline visit and at the first follow-up visit how many hours per day they were exposed to SHS at work and during their leisure time. Categorical responses were required for both questions: 0-0.5 hours, 0.5-2 hours, 2-5 hours and more than 5 hours.

Members of Control Group III were recruited by means of an online advertisement looking for non-smokers that were exposed to SHS on a regular basis, either privately or at work. In this group, no workplace badge data was collected.

Ethical approval was obtained from the EKBB (Ethics committee of both cantons of Basel) and all participants signed an informed consent before every examination (Reference no. EK: 317/09).

Laboratory analyses

MoNIC badges are glass fibre filters that are washed with distilled water, methanol and dichloromethane (CH_2Cl_2), impregnated with about 5mg sodium bisulphate per filter and placed in an air-tight plastic case (20). This method was developed by the Institute of Work and Health in Lausanne (20) and adapted from that proposed by Hammond and Ogden (21, 22). Badges were always transported between study centres, participants, and the laboratory in these air-tight cases. The amount of nicotine on the badge was determined by gas chromatography. The extracted nicotine from the filter, known to take in air at a rate of 10 ml/min, was multiplied by 1000 to mimic an average respiration rate of 10 l/min which corresponds to normal sedentary behaviour (23). The number of passively smoked cigarettes was calculated by assuming 0.2 mg nicotine per cigarette.

Salivary cotinine and nicotine levels were obtained during the medical examination without any stimulation using a plastic straw, and quantified by liquid-liquid (liq-liq)extraction with CH_2Cl_2 and GC-NPD (gas chromatography-nitrogen-phosphorus detector; working range: 0.1-500 ng/ml. limit of quantification: 0.1 ng/ml) (20, 24).

The final batch of saliva samples from control group members were excluded from the data analysis due to inconsistencies in lab procedures.

Data analysis

Data were analysed using Stata 10.1. Workplace exposure of participants was calculated from the MoNIC badge placed at the workplace. If two badges were placed in a venue, we used the value from the section where the buffet was located for our calculations as waiting staff spends more of their time there. We used a time-weighted average, based on a shift of 8 hours/day for full-time employees. Average workplace concentration was multiplied by workload *0·6 taking into account holidays and considering the fact that nicotine levels decrease when a venue is closed and staff is absent. This factor was estimated from a previous study of continuous $PM_{2.5}$ measurements in smoking environments (11). Longitudinal comparisons were conducted by means of the Kruskal-Wallis equality-of-populations rank test that compares three or more unmatched groups. In cross-sectional comparisons between different venue types, the non-parametric Mann-Whitney test for two unpaired groups was applied.

RESULTS

We performed 225 badge measurements in 193 hospitality venues during baseline visits. First follow-up visits were conducted 199 days later, on average, in 51 venues with 58 badges. At the second follow-up, 42 badges were placed in 36 venues. The intervention group comprised 56 persons at baseline, 44 persons at follow-up 1 (79 %) and 42 at follow-up 2 (75 %). These were compared to the control groups: 6 persons working in smoking venues that did not change their rule (control group I), 14 hospitality workers that had always worked in smoke-free environments (Control Group II) and 16 persons that are regularly exposed to SHS privately or at work without being employed in the hospitality sector (Control Group III). Two members of Control Group I returned for a second examination (33%), while 10 (62.5%) and 5 (31.3%) participants in Control Group III underwent second and third examinations, respectively (Figure 4-1).

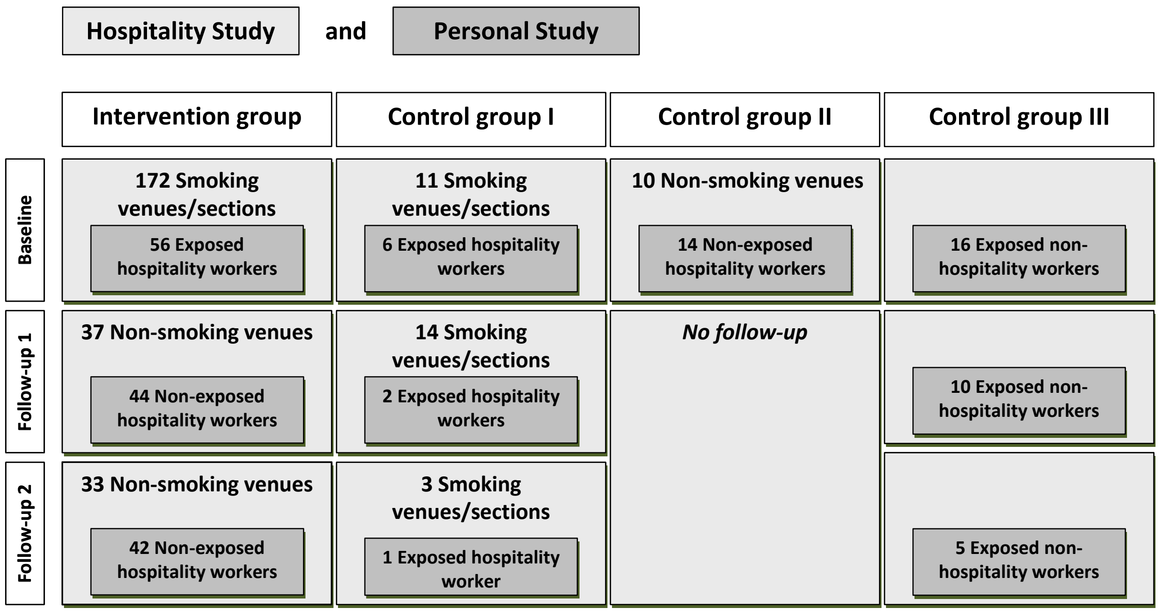

Figure 4-1 Study design with number of venues and study participants

At baseline, badge analysis of all smoke-exposed hospitality venues yielded an average value of 4.48 (95%-CI: 3.7 to 5.25; n=214) cigarette equivalents (CE)/day. This means that a person present in a smoke-exposed venue for 24 hours would inhale a similar amount of smoke as a person actively smoking 4.48 cigarettes. Badges from smoking venues from where at least one study participant was included in the study (n=50), yielded an average exposure of 4.00 (95%-CI: 2.48 to 5.51) CE/day. The other 164 badges from venues without study participants had average values of 4.62 (95%-CI: 3.72 to 5.53) CE/day. The type of smoking regulation in place clearly influenced SHS exposure, with smoking venues reaching an average of 6.12 (4.71 to 7.53; n=82) CE/day (Figure 4-2).Levels in smoking sections yielded 4.39 (3.24 to 5.54; n=93) CE/day, venues with a time regulation that prohibited smoking during mealtimes 1.95 (0.45 to 3.45; n=11) CE/day and open, non-smoking sections averaged 0.92 (0.5 to 1.35; n=28) CE/day. This was still significantly higher than values in completely non-smoking venues (Control Group II) at 0.13 (0.01 to 0.24; n=11) CE/day ($p<0.001$). There was only one non-smoking section in our sample that was separated by a door.

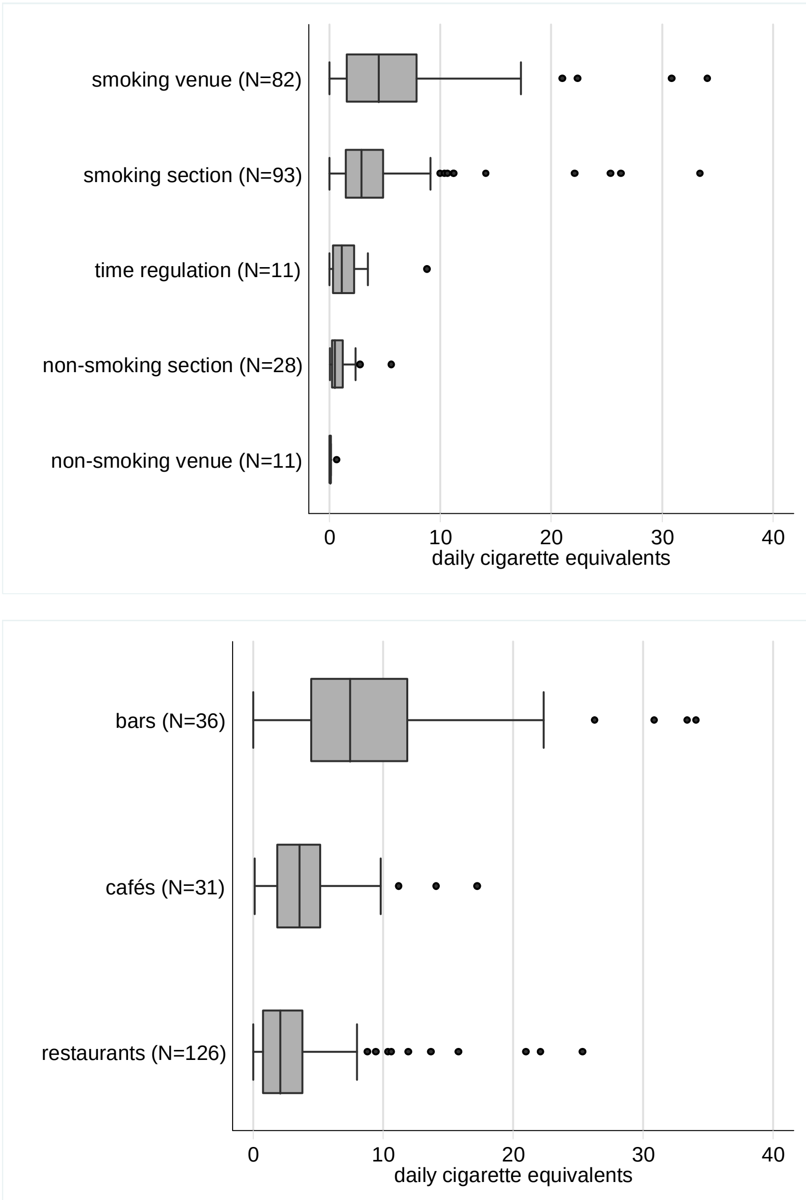

Figure 4-2 Cross-sectional comparison of SHS levels in different types of hospitality venues (n=193) with different smoking policies at baseline (n=225)

[1] time regulation refers to venues with temporal ban, ex. during mealtimes

[2] A Cigarette equivalent (CE)/day is the equivalent amount of smoke of one actively smoked cigarette that a smoke-exposed person inhales

There were also substantial differences in SHS exposure according to the type of hospitality venue. At baseline, the highest exposure was found in bars with 9.99

(7.06-12.92; n=36) CE/day, followed by cafés (4.54; 95% CI: 3.12-5.96; n=31) and restaurants (3.28; 2.53-4.02; n=126) (Figure 4-2).

At the time of the first follow-up, the exposure had significantly decreased to 0.3 (0.21 to 0.38; n=37) in all venues that had introduced a smoking ban (i.e. intervention group), irrespective of venue type ($p<0.001$). The type of venue was no longer an influential factor. Six months later, at follow-up 2, levels remained low at 0.33 (0.17 to 0.49; n=33) CE/day. In venues that had not implemented a smoking ban (Control Group I), smoke levels at follow up 1 were, on average, 3.37 (1.29 to 5.44; n=14) CE/day.

Table 4-1 shows the results of the personal study. At follow-up, personal badges showed significant decreases in exposure ($p<0.001$), although this decrease was not as pronounced as for workplace badges. Restricting the pre/post ban comparison of the intervention group to only the 33 persons who participated in all three examinations gave similar results (mean time-weighted average of workplace exposure at baseline: 2.67 (1.38 to 3.96) CE/day, at first follow-up: 0.14 (0.1 to 0.18) CE/day, and at second follow up: 0.19 (0.09 to 0.28) CE/day). Participants that were lost to follow-up had lower workplace exposure at baseline ($p=0.004$), in the personal badges this difference was less pronounced ($p=0.171$). In the questionnaire, 14.7% of the intervention group reported the same length of exposure per day at follow-up as at baseline, while the remainder reported lower values (85.3%). Regarding exposure in their leisure time, 30.3% stated a lower number of exposed hours, 66.7% remained the same and one person reported an increase in exposed hours.

Addressing the second aim of the study, the personal badge results were compared with salivary nicotine and cotinine levels. Spearman's rank correlation coefficients were 0.17 for badge versus nicotine (p-value: 0.04; n=137) and 0.3 for badge versus cotinine (p-value<0.001; n=137). Nicotine and cotinine showed a correlation of 0.41 (p-value: <0.001; n=140). The time-weighted average of the workplace badge yielded correlation coefficients of 0.17 with salivary nicotine (p-value: 0.07; n=116), 0.23 with salivary cotinine (p-value: 0.01; n=116) and 0.56 with the personal badge (p-value<0.001; n=142).

DISCUSSION

The smoking ban led to a significant decrease in exposure for all participants that worked in an environment where a new law was introduced. SHS levels in all types of venues dropped to nearly zero after the ban. At baseline, the current smoking policy in the venue and the type of venue clearly influenced the number of passively smoked cigarettes per day, as calculated from air measurements in hospitality venues. Venues where participants worked did not significantly differ from venues from where there were no participants. Bars had higher values than cafés, which in turn yielded a higher exposure than restaurants. Some restaurants had special time regulations such as smoke-free mealtimes, which led to a further decrease in average levels. Badge readings from smoking rooms were only slightly higher than those from smoking sections in mixed rooms, i.e. rooms containing both smoking and non-smoking sections. Although non-smoking sections had lower levels, they were, nevertheless, significantly higher than in entirely smoke-free locations. These results are in line with previous studies that found that designated non-smoking sections were inadequate measures for protecting people from SHS (10,11,25). Moreover, studies have shown that only the implementation of a comprehensive law results in widespread acceptance by the population (26,27).

Comparison of various exposure proxies

In this study, salivary data were compared with personal and workplace badge measurements as well as questionnaire data. There was poor correlation between these indicators. The personal and the workplace badges had the highest correlation coefficient: 0.56 (p-value < 0.001; $n = 142$). One drawback of personal badge measurements is that participants did not always clearly state where the badge was worn, be it at home, work or both. The personal badge measurement was also greatly affected by the behaviour on that given day, e.g. whether the wearer went out to a place where smoking was allowed. In some instances, the personal badges captured only exposure outside of the workplace, as some study participants did not work during the 24 hours prior to the health examination. The results of these badges are, therefore, specific to a given day and should be treated with caution. The workplace badge, however, was exposed for a period of one week, thus representing the average exposure environment in the workplace.

Salivary measurements are subject to variations in individual metabolism, as are all biomarkers. Cotinine reflects exposure to nicotine and is, therefore, very specific for tobacco exposure (28). Timely sampling is crucial, due to the rapid degradation of the compound, and results also depend on how recently the exposure occurred (29). They would have been more likely to reflect workplace SHS exposure if participants were sampled immediately after leaving the workplace. Unfortunately, this was not possible in the context of this study. But other studies face similar problems, in particular if the exposure is not as clearly specified as in hospitality workers.

Our salivary samples do, however, allow us to identify potential smokers from a supposedly non-smoking sample. The Society for Research on Nicotine and Tobacco (SRNT) subcommittee suggests that smokers are likely to have salivary cotinine values of > 15 ng/ml (30). Thus, salivary measurements will be useful to ensure that future health analyses are restricted to non-smokers only. Self-reported data in questionnaires are prone to recall bias and risk imprecision (28). Nevertheless, participants confirmed their overall declining exposure at work with the responses given in the questionnaire. Concerning exposure out of working hours, a declining tendency was observed, but two thirds reported unchanging conditions.

We calculated a time-weighted average for the workplace badge to better approximate the true exposure at work, taking into account the participants' individual workload. For this reason, workplace badges likely provided the most relevant measure of changes in exposure after the smoking ban introduction. Consequently, these measurements were used to assess the relationship between changes in workplace exposure and cardio respiratory outcomes.

Strengths and limitations

A key strength of our study is that different methods were applied and compared in order to assess the personal exposure of the study participants. In addition to the more standard methods of salivary nicotine and cotinine and questionnaire-based data, the MoNIC badge was used. This passive sampler is very simple and easy to use, providing a specific value for nicotine without a proxy. Although SHS is the most important contributor, PM2.5 measurements can be confounded by other sources such as candles, kitchen fumes or other air pollutants (31,32). A large number of venues were measured before the smoking ban, representing a range of venue types and smoking policies. Some limitations to our study have been identified. The recruitment process was long, taking place both before and after implementation of the new law, and this could have led to a selection bias. Presumably, venues less willing to participate would have had higher exposure levels. Restaurants were overrepresented in our study compared to bars, and restaurants had lower SHS levels than bars. Consequently, an underestimation of the true average SHS levels in Swiss hospitality workers is highly likely. A similar situation can be assumed in the recruitment of participants. Heavily exposed workers were often determined to be smokers, and were not eligible to participate. Those workers that consented to participate were probably more health conscious and more likely to work in venues with lower exposures.

CONCLUSIONS

These results support previous findings that a smoking ban leads to significantly lower SHS levels in hospitality venues, provided that the venue is completely smoke-free. A time-weighted average of the workplace badge turned out to be the most reliable method to determine changes in personal SHS exposure at the workplace. The personal exposure of hospitality workers was shown to decline after the implementation of a smoking ban. A comprehensive national law is needed in hospitality venues in Switzerland in order to fully protect the population from SHS, particularly hospitality personnel in their professional environment.

Competing interests

The authors declare that they have no competing interests

Author's contributions

SR conducted the study, analysed the data and drafted the manuscript. CKH contributed to the design of the study, performed the laboratory analysis and revised the manuscript. GFB contributed to the design of the study and revised the manuscript. SH designed a questionnaire and revised the manuscript. MR designed the study, analysed the data and revised the manuscript. All authors read and approved the final manuscript.

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Table 4-1 Different personal measurement methods at baseline, follow-up 1 and follow-up 2

			Baseline		Follow-up 1		Follow-up 2	
		n[2]	Arithmetic mean (95% CI)	n	Arithmetic mean (95% CI)	n	Arithmetic mean (95% CI)	p-Value
Personal badge (cigarette equivalents/day)	Intervention group	53	2.18 (1.31 to 3.05)	41	0.53 (0.39 to 0.67)	41	0.25 (0.13 to 0.36)	<0.001
	Control Groups I+III	20	1.69 (0.74 to 2.64)	11	1.17 (0.57 to 1.77)	5	1.22 (0.10 to 2.34)	0.892
	Control Group II	14	0.41 (0.25 to 0.57)					
Work place badge (cigarette equivalents/day)*	Intervention group	50	4.82 (3.14 to 6.50)	40	0.27 (0.19 to 0.34)	36	0.31 (0.17 to 0.46)	<0.001
	Control Groups I	6	3.85 (-0.51 to 8.21)	2	2.15 (-23.66 to 27.96)	1	0.22	0.561
	Control Group II	12	0.27 (0.08 to 0.47)					
Time weighted average of work badge (cigarette equivalents/day)*	Intervention group	50	2.65 (1.69 to 3.62)	40	0.15 (0.11 to 0.20)	36	0.18 (0.10 to 0.27)	<0.001
	Control Groups I	6	2.24 (-0.30 to 4.79)	2	1.25 (-13.80 to 16.31)	1	0.30	0.561
	Control Group II	12	0.14 (0.03 to 0.25)					
Salivary nicotine (ng/ml)	Intervention group	44	1.99 (0.98 to 3.00)	35	2.42 (-0.01 to 4.86)	36	2.81 (-0.12 to 5.75)	0.227
	Control Groups I+III	14	1.45 (-0.05 to 2.95)	5	4.24 (-5.49 to 13.97)	1	7.80	0.699
	Control Group II	5	2.38 (-3.95 to 8.71)					
Salivary cotinine (ng/ml)	Intervention group	44	0.67 (0.04 to 1.30)	35	2.75 (0.32 to 5.17)	36	0.81 (0.00 to 1.61)	0.243
	Control Groups I+III	14	1.54 (-0.43 to 3.51)	5	3.84 (-2.56 to 10.24)	1	0.13	0.329
	Control Group II	5	2.82 (-4.73 to 10.37)					

**no data for control group III*

[2] *if two persons worked in the same venue, this badge was counted double*

References

1. Keller R, Prinz-Kaltenborn R, Krebs H, Hornung R. Exposure to and annoyance with second-hand smoke in Switzerland: results of the Tobacco Monitoring survey. Sozial- und Präventivmedizin. 2005;50(6):370-7.

2. Semple S, Maccalman L, Naji AA, Dempsey S, Hilton S, Miller BG, et al. Bar workers' exposure to second-hand smoke: the effect of Scottish smoke-free legislation on occupational exposure. The Annals of Occupational Hygiene. 2007;51(7):571-80.

3. Jamrozik K. Estimate of deaths attributable to passive smoking among UK adults: database analysis. BMJ. 2005;330(7495):812.

4. Hyland A, Barnoya J, Corral JE. Smoke-free air policies: past, present and future. Tob Control. 2012;21(2):154-61.

5. WHO Framework Convention on Tobacco Control (FCTC). Geneva: World Health Organisation; 2003.

6. Verordnung zum Schutz vor Passivrauchen (Stand am 1. Mai 2010) (Legal ordinance on protection from passive smoking (status on 1st May, 2010)), (2009).

7. Lopez MJ, Nebot M, Schiaffino A, Perez-Rios M, Fu M, Ariza C, et al. Two-year impact of the Spanish smoking law on exposure to secondhand smoke: evidence of the failure of the 'Spanish model'. Tobacco Control. 2011;21(4):407-11.

8. Connolly GN, Carpenter CM, Travers MJ, Cummings KM, Hyland A, Mulcahy M, et al. How smoke-free laws improve air quality: a global study of Irish pubs. Nicotine & Tobacco Research. 2009;11(6):600-5.

9. Villarroel N, Lopez MJ, Sanchez-Martinez F, Fernandez E, Nebot M. (Second-hand smoke exposure in hospitality venues in Barcelona: measurement of respirable particles). Gaceta Sanitaria. 2011;25(3):220-3.

10. Cains T, Cannata S, Poulos R, Ferson MJ, Stewart BW. Designated "no smoking" areas provide from partial to no protection from environmental tobacco smoke. Tobacco Control. 2004;13(1):17-22.

11. Huss A, Kooijman C, Breuer M, Bohler P, Zund T, Wenk S, et al. Fine particulate matter measurements in Swiss restaurants, cafes and bars: what is the effect of spatial separation between smoking and non-smoking areas? Indoor Air. 2010;20(1):52-60.

12. Lee K, Hahn EJ, Robertson HE, Lee S, Vogel SL, Travers MJ. Strength of smoke-free air laws and indoor air quality. Nicotine & Tobacco Research. 2009;11(4):381-6.

13. Semple S, Creely KS, Naji A, Miller BG, Ayres JG. Secondhand smoke levels in Scottish pubs: the effect of smoke-free legislation. Tobacco Control. 2007;16(2):127-32.

14. Barnoya J, Arvizu M, Jones MR, Hernandez JC, Breysse PN, Navas-Acien A. Secondhand smoke exposure in bars and restaurants in Guatemala City: before and after smoking ban evaluation. Cancer Causes Control. 2011;22(1):151-6.

15. Bohac DL, Hewett MJ, Kapphahn KI, Grimsrud DT, Apte MG, Gundel LA. Change in indoor particle levels after a smoking ban in Minnesota bars and restaurants. American Journal of Preventive Medicine. 2010;39(6 Suppl 1):S3-9.

16. Reijula JP, Johnsson TS, Kaleva PS, Reijula KE. Exposure to tobacco smoke and prevalence of symptoms decreased among Finnish restaurant workers after the smoke-free law. American Journal of Industrial Medicine. 2012;55(1):37-43.

17. Benowitz NL. Biomarkers of environmental tobacco smoke exposure. Environmental Health Perspectives. 1999;107 Suppl 2:349-55.

18. Al-Delaimy WK. Hair as a biomarker for exposure to tobacco smoke. Tobacco Control. 2002;11(3):176-82.

19. Centers for Disease Control and Prevention (US). The Health consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General. Atlanta (GA): U.S. Department of Health and Human Services, 2006.

20. Huynh CK, Moix J, Dubuis A. (Development and application of the passive smoking monitor MoNIC). Revue Médicale Suisse. 2008;4(144):430-3.

21. Hammond SK, Leaderer BP. A diffusion monitor to measure exposure to passive smoking. Environmental Science & Technology. 1987;21(5):494-7.

22. Ogden M, Maiolo K. Comparative Evaluation of Diffusive and Active Sampling Systems for Determining Airborne Nicotine and 3-Ethenylpyridine. Environmental Science & Technology. 1992;26(6):1226-34.

23. Durham AD, Bergier S, Morisod X, Locatelli I, Zellweger JP, Huynh CK, et al. Improved health of hospitality workers after a Swiss cantonal smoking ban. Swiss Medical Weekly. 2011;141:w13317.

24. Huynh CK, Moix J-B, Dubuis A, Varonier HS, Stauffer Babel R, Celio M, et al. Second Hand Tobacco Smoke exposure in Switzerland. CHUV Research Day; Lausanne2009. p. 26.

25. Erazo M, Iglesias V, Droppelmann A, Acuna M, Peruga A, Breysse PN, et al. Secondhand tobacco smoke in bars and restaurants in Santiago, Chile: evaluation of partial smoking ban legislation in public places. Tobacco Control. 2010;19(6):469-74.

26. Apsley A, Semple S. Secondhand smoke levels in Scottish bars 5 years on from the introduction of smoke-free legislation. Tobacco Control. 2012;21(5):511-3.

27. Cooper J, Borland R, Yong HH, Hyland A. Compliance and support for bans on smoking in licensed venues in Australia: findings from the International Tobacco Control Four-Country Survey. Australian and New Zealand journal of public health. 2010;34(4):379-85.

28. Benowitz NL. Cotinine as a biomarker of environmental tobacco smoke exposure. Epidemiologic Reviews. 1996;18(2):188-204.

29. Benowitz NL, Hukkanen J, Jacob P, 3rd. Nicotine chemistry, metabolism, kinetics and biomarkers. Handbook of experimental pharmacology. 2009(192):29-60.

30. SRNT Subcommittee on Biochemical Validation. Biochemical verification of tobacco use and cessation. Nicotine & Tobacco Research. 2002;4(2):149-59.

31. Agbenyikey W, Wellington E, Gyapong J, Travers MJ, Breysse PN, McCarty KM, et al. Secondhand tobacco smoke exposure in selected public places (PM2.5 and air nicotine) and non-smoking employees (hair nicotine) in Ghana. Tobacco Control. 2011;20(2):107-11.

32. Daly BJ, Schmid K, Riediker M. Contribution of fine particulate matter sources to indoor exposure in bars, restaurants, and cafes. Indoor Air. 2010;20(3):204-12.

5 ARTICLE 2: The effect of workplace smoking bans on heart rate variability and pulse wave velocity of non-smoking hospitality workers

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ABSTRACT

Objectives. To investigate the effect of a change in second hand smoke (SHS) exposure on heart rate variability (HRV) and pulse wave velocity (PWV), this study utilized a quasi-experimental setting when a smoking ban was introduced.

Methods. HRV, a quantitative marker of autonomic activity of the nervous system, and PWV, a marker of arterial stiffness, were measured in 55 non-smoking hospitality workers before and 3 to 12 months after a smoking ban and compared to a control group that did not experience an exposure change. SHS exposure was determined with a nicotine specific badge and expressed as inhaled cigarette equivalents per day (CE/d).

Results. PWV and HRV parameters significantly changed in a dose dependent manner in the intervention group compared to the control group. A one CE/d decrease was associated with a 2.3% (95% CI: 0.2 to 4.4; p=0.031) higher root mean square of successive differences (RMSSD), a 5.7 % (95% CI: 0.9 to 10.2; p=0.02) higher high frequency (HF) component and a 0.72% (95 % CI: 0.40 to 1.05; p<0.001) lower PWV.

Conclusions. PWV and HRV significantly improved after introducing smoke-free workplaces indicating a decreased cardiovascular risk.

INTRODUCTION

Several epidemiological studies from various countries have shown the beneficial effects of a public indoor smoking ban on cardiovascular health, especially acute myocardial infarction (AMI). In Indiana, USA, hospital admission rates for AMI declined by 50% primarily among non-smokers (1). In Helena, Montana rates decreased by 40%, but returned to former levels after ban suspension (2), while decreased levels stayed low in Pueblo County after a longer enforcement period (3). Studies in European cities suggest less pronounced decreases (4). In Scotland, AMI rates decreased by 17% after the ban compared to a 4% decrease in England that did not have a ban (5). A recent meta-analysis including 45 studies calculated significantly lower hospital admission rates for both coronary events (RR: 0.848; 95% CI: 0.816-0.881) as well as for other heart diseases (RR: 0.610; 95% CI: 0.440-0.847) after introducing a comprehensive smoking ban (6). However, most studies lack a control group as well as exact information on smoking status and exposure because they were conducted on a population level only. To assess the mechanistic public health impact of public smoking bans, population-based, sensitive measures beyond AMI are needed.

Heart rate variability (HRV) is a quantitative marker of autonomic activity of the nervous system and lower HRV is associated with higher cardiovascular morbidity and mortality (7). The main influencing factors are sex, age, physical activity, blood pressure and smoking status (8). In a study by Pope et al., acute exposure to SHS alternating with non-exposed periods led to consistently lower HRV measures during exposure (9). A cross-sectional analysis showed that long-term SHS exposed persons for >2h/day have higher High Frequency (HF), lower total power (TP), Low Frequency (LF) and a lower LF/HF ratio than unexposed people (10) . These are important frequency-domain HRV measures providing further insight on fluctuations of HR (11). Chen et al. showed that HRV was lower in mice during and after exposure to second-hand smoke (SHS) (12). No longitudinal study on long-term SHS exposure and HRV has been conducted so far.

Pulse wave velocity (PWV) provides a measure of arterial stiffness (13) which is an important indicator of cardiovascular risk and atherosclerosis (14). In addition arterial stiffness is a powerful predictor of all-cause mortality (13, 15). An increase of PWV was observed after acute exposure to SHS (16) and after smoking one cigarette (17). Arteries such as the aorta and the femoral artery are composed of different amounts of smooth muscle cell layers and acute changes in arterial stiffness may reflect changes in arterial tone due to autonomic innervation or changes in endothelial function (18).

In another study PWV was found to be higher among smokers than non-smokers but smoking cessation did not lead to any significant changes (19). A prospective cohort study found a significant relationship between the number of cigarettes smoked per day and the annual rate of change in PWV (20). Long-term exposure to SHS and its impact on arterial stiffness have not been examined as yet.

When Switzerland introduced a smoking ban in May 2010, the national law left room for exceptions (21). While several cantons – administrative zones in Switzerland - completely banned smoking venues and rooms, in other cantons either small smoking venues or separated smoking rooms were still allowed. This unique situation served as a quasi-experimental setting for our prospective study. The aim was to directly relate SHS exposure in non-smoking hospitality workers before and after introduction of the smoking ban to HRV and arterial stiffness. We further compared possible changes in the intervention group which was subject to the introduction of smoke free workplaces to the control group that did not experience any changes in SHS exposure at the work place.

METHODS

Study population

This is a quasi-experimental study comparing non-smoking employees for whom second hand smoke exposure at work was eliminated as a result of the new smoking regulations (intervention group) with non-smoking employees that did not undergo any change in exposure (control groups). The intervention group consisted of participants who had worked for at least 1 year in venues where smoking was either partially or completely allowed prior to the introduction of the smoking ban (n=55). After introduction of the smoking ban, the intervention group was no longer exposed to SHS at work. The control group consisted of individuals who were exposed to SHS both before and after the implementation of the smoking ban because of the exceptional rules described above (n=7) and non-smokers that were regularly exposed to SHS at work or in private without being employed in the hospitality sector (n=16). Due to difficulties in recruitment of non-smoking hospitality workers, we additionally included a supplementary group of 14 non-smoking hospitality workers at baseline, who worked in a smoke-free environment at all times (labelled supplementary group).

In the intervention group, a baseline examination was conducted within the 3 months prior to the introduction of the smoking ban. Subsequently, two follow-up examinations were conducted at 3-6 months and 9-12 months after the smoking ban introduction. The unexposed study participants constituting the supplementary group were examined once; all others were invited for examinations three times. Intervals between examinations were also about six months.

Recruitment procedure

A list of hospitality venues in the cantons of Zurich, Basel City and Basel County was created using the digital Swiss phonebook from 2009. Each venue received a letter that was followed-up by a phone call and a visit two weeks later.

Screening questionnaires were distributed to the waiting staff, for providing information on the eligibility criteria which were being between 18 and 65 years of age, working at least half-time, having worked for at least one year in the hospitality sector and having been a non-smoker for at least 5 years. Eligible study participants were invited to a health examination, which was carried out in one of the two study centres in Basel City and Zurich.

The non-hospitality workers were recruited by means of an online advertisement looking for non-smokers that were exposed to SHS on a regular basis, either privately or at work.

Health examinations

The health examinations comprised cardiovascular and respiratory tests as well as a computer-based interview. About 20 minutes into the health examination, electrocardiograms (ECG) were continuously recorded for 10 minutes with a 7-lead digital recorder (SEER Light, GE Healthcare, Freiburg, Germany) with participants in the supine position. ECGs were stored and subsequently analysed on a PC MARS workstation (GE Healthcare). Beat annotations were automatically assigned by the GE software and manually reviewed by an investigator blinded to the exposure status of participants to ensure proper annotation of non-sinus beats and artefacts. Only normal sinus beats were used in the calculation of HRV metrics. The duration between the R waves of consecutive normal sinus beats (N-N intervals) was identified and only beats with an N-N interval between 0.4 and 2.0 s and ratio between 0.8 and 1.2 were included in the analysis.

Calculations for time domain [standard deviation of N-N intervals (SDNN); square root of the mean squared differences of successive N-N intervals (rMSSD)] and frequency domain [low-frequency (LF) power (0.04-0.15 Hz), high-frequency (HF) power (0.04-0.15 Hz), and their ratio (LF/HF)] HRV parameters were evaluated on non-overlapping 5-min intervals of ECG data using standard techniques (Task Force of the European Society of Cardiology 1996). Only 5 minute intervals with a ratio of N-N/R-R intervals >90% were included in our analyses.

Subsequently, PWV and blood pressure were measured using a VaSera VS-1500N device (Fukuda Denshi Co., Tokyo, Japan). Participants were in supine position and at rest for at least 10 minutes beforehand. If the first two measures were more than 0.5 m/s apart, a third measurement was taken. For analysis the average of the two more similar measurements was used.

Exposure measurements

SHS was measured using newly developed MONIC passive sampling badges made of glass fibre. The amount of nicotine on a badge was determined by gas chromatography and used to calculate the number of passively smoked cigarettes(CEs)/day assuming a nicotine content of 0.2 mg/cigarette and an average ventilation rate of 10 L/min (22),(23).

In the hospitality venues that agreed to participate, at least one MoNIC badge was placed for one week, often near the bar where waiting personnel spend much of their working time. We calculated for each hospitality worker a time-weighted average workplace exposure (24) by multiplying their average workplace concentration by their workload (in percentage of full time equivalent) and by 0.6, which represents presence time at the work place including holidays and considering the fact that nicotine levels decrease when a venue is unattended(24). . For non-hospitality workers average SHS exposure was obtained from a personal badge that participants wore on themselves at work and in private on a typical day.

Statistical Analysis

Longitudinal analyses were conducted with two statistical approaches. First, for the intervention group and the control group a pre/post ban exposure variable was derived by defining baseline data of both groups as pre-ban and the two follow-up examinations as post ban although in the control group no ban was introduced. In order to increase statistical power we did not differentiate between the follow-up examinations and calculated an overall effect. For each log-transformed outcome a linear mixed effects model with a random subject intercept was fit including a study group by pre/post ban interaction term. HRV analyses were adjusted for age, sex, BMI and season, PWV additionally for time of day and systolic blood pressure as continuous variables. Systolic blood pressure was adjusted for age, sex, BMI, season and self-reported asthma. Finally, we calculated crude and adjusted values of the health outcomes prior and after the ban for both groups. Secondly, covariate-adjusted exposure response associations were calculated with a random intercept model using the estimated work place SHS exposure at the time of each health examination as explanatory variable using data from all study participants, including the unexposed supplementary group.

Data were analysed using Stata 10.1 (StataCorp LP, College Station, TX).

RESULTS

Exposure of the study population

Our study sample comprised 92 participants, 55 in the intervention group, 23 in the control group and 14 in the supplementary group. Groups did not differ in terms of sociodemographic factors or health status, except for age, self-reported asthma and physical activity (Table 5-1). There were no diabetics in our sample. Average exposure in the intervention group at baseline was 2.56 (95% CI: 1.70 to 3.44) cigarette equivalents per day (CE/day) and 0.16 (95% CI: 0.13 to 0.20) CE/day at follow-up resulting in an exposure reduction of 2.40 CE/day (Table 5-1). In the exposed control group exposure at baseline was 2.07 (95% CI: 0.96 to 3.18) CE/day and 1.59 (95% CI: 0.67 to 2.50) CE/day at follow-up.

Heart Rate Variability

From the HRV analyses 2 observations from the intervention group and 5 from the control group were excluded due to missing data (n=1) or insufficient quality (n=6). At baseline, adjusted HRV parameters did not differ between the intervention and the exposed control group (Table 5-2). After the introduction of the smoking ban, SDNN, RMSSD, HF, LF/HF and Total Power significantly diverge between the two groups (Figure 5-1). All these parameters increase in the intervention group while decreasing in the control group except the LF/HF ratio which goes in the opposite direction, leading to a significant change in the intervention group relative to the exposed control group after implementation of the smoking ban. The exposure-response model (Table 5-3) shows significant increases of 2.3% (95% CI: 0.2 to 4.4;

p=0.031) and 5.7 % (95% CI: 0.9 to 10.2; p=0.02) per decrease in CE/day for RMSSD and HF, respectively. SDNN and Total Power are associated with an increase of 1.8 % (95% CI: -0.1 to 3.8; p=0.069) and 4.1% (95% CI: 0.0 to 8.0; p=0.51), while the LF/HF ratio significantly decreases by -5.7% (95% CI: -9.1 to -2.4); p=0.001) per decrease in CE/day. LF does not change materially. For comparison, age-dependent changes in HRV parameters obtained from the same model are shown in Table 5-3.

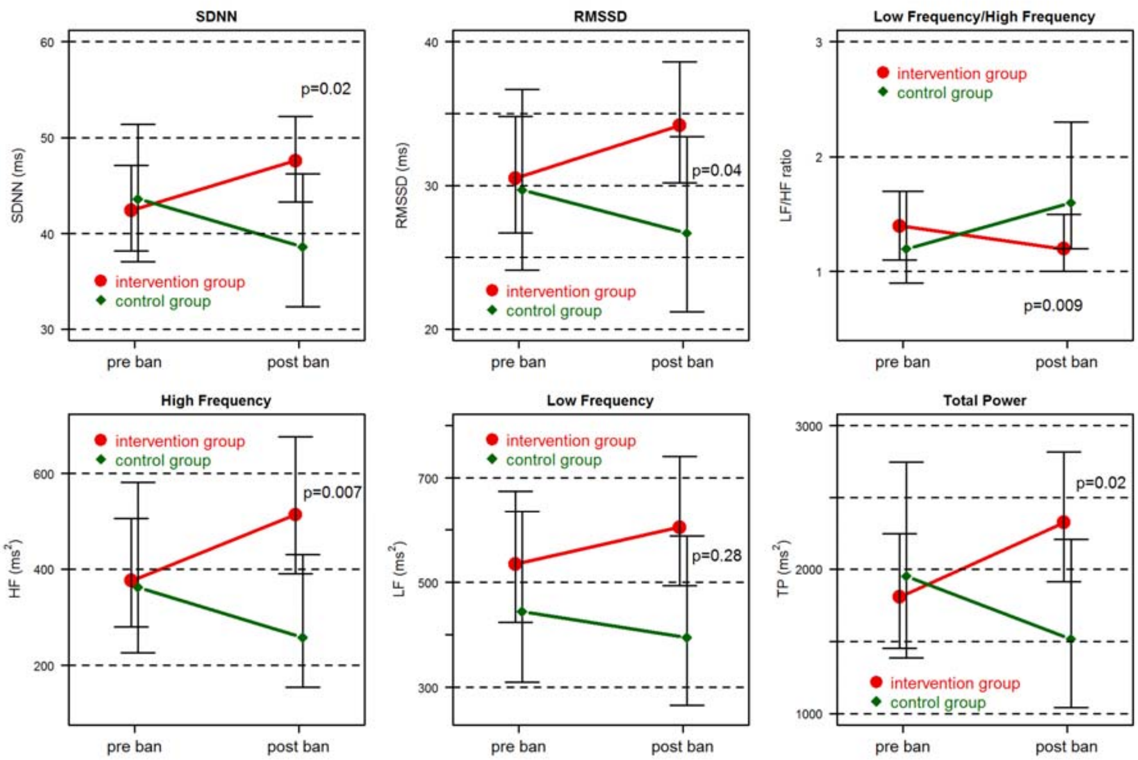

Figure 5-1 Covariate-adjusted Heart Rate Variability parameters at baseline and follow-up, Switzerland 2010/2011

P-values refer to the change in the intervention group relative to the control group.

SDNN= standard deviation of NN intervals; RMSSD=root mean square of successive difference

Pulse Wave Velocity

For the arterial stiffness analyses two participants had missing data and technical problems resulted in the loss of five observations for the PWV measurements (4 intervention, 1 control). Table 5-2 shows crude and adjusted values of PWV for the intervention and control group. Figure 5-2 illustrates the changes in adjusted values comparing the intervention and control groups. Differences in PWV are not significant although the intervention group shows a steady decrease over the year, an effect not observed in the control group. Systolic blood pressure decreases in the intervention group and increases in the control group.

According to the exposure-response model (Table 5.3) PWV declines with each CE/day decrease by 0.72% (95% CI: 0.40 to 1.05; p<0.001) whereas the decrease for systolic blood pressure is not statistically significant.

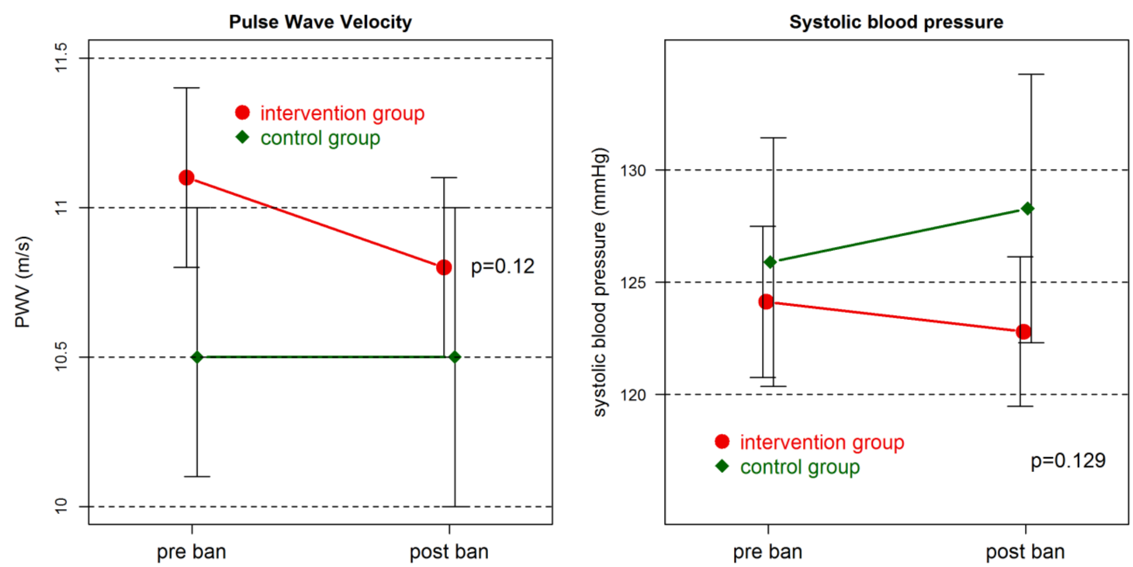

Figure 5-2 Covariate-adjusted Pulse Wave Velocity and systolic blood pressure at baseline and follow-up, Switzerland 2010/2011

P-values refer to the change in the intervention group relative to the control group

DISCUSSION

The smoking ban implementation led to statistically significant improvements in HRV parameters in non-smoking hospitality workers within 12 months. HRV increased in the intervention group and PWV decreased compared to the control group that did not experience any changes in SHS exposure.

This study addresses several research gaps that the Institute of Medicine 2010 report on SHS exposure and cardiovascular effects identified (25): It directly examines the exposure-response relationship of individual-level SHS exposure to HRV and arterial stiffness and accounts for potential confounders, including other risk factors for cardiovascular events. It also compares possible changes in an intervention group where smoke free workplaces were introduced to a control group that did not experience a change in SHS exposure.

Comparison with the literature

Our results on HRV are in line with the only other study looking into long-term effects of SHS on HRV reporting trends of lower levels in SDNN, Total Power and HF in subjects that were exposed to SHS for >2h/d compared to unexposed subjects in a cross-sectional setting (10). Our findings are also supported by other studies that looked at acute effects of SHS on HRV and found consistent decreases in SDNN as soon as subjects were exposed (9) or right after exposure (26, 27). The effect of active smoking on heart rate variability has been studied extensively. While several studies found diminished HRV in heavy smokers (28-30), others did not confirm this (31, 32). A study examining the effect of smoking cessation on HRV recorded a significant increase one day after cessation in heavy smokers that although diminished, persisted one month after cessation (33). This effect is in line with another study looking at regular smokers (34).

Interpretation of our results

No significant difference in HRV parameters between the intervention and the exposed control group could be detected at baseline. SDNN, reflecting the overall variability of HRV, increased by 1.8% per decrease in CE/day, which is more than the 1.5% decrease of SDNN per year of life according to the same exposure-response model. Applying the average exposure reduction of 2.4 CEs/day that we estimated in this study, this effect corresponds to a delay of roughly three years in HRV reduction. RMSSD and HF describing parasympathetic activity both increased significantly. LF did not change measurably while the LF/HF ratio significantly decreased. These alterations support former published evidence suggesting that passive smoking increases the sympathetic drive and reduces parasympathetic modulation as well as overall HRV (35).

PWV was higher at baseline in the intervention group than in the exposed control group. During the study the two groups drew closer together although the ban effect was not significant. In the exposure-response model, PWV significantly declined by 0.72% per decrease in CE/day, which corresponds to a ban effect of about 2.5 years of life. The somewhat discordant result of the exposure-response model compared to the pre/post model means that PWV was strongly correlated with SHS exposure at the workplace but changes within one year were small. This pattern would be consistent with a more chronic effect of SHS assuming that measured exposure at the workplace at baseline is representative for chronic exposure.

Strengths and limitations

To the best of our knowledge this is the first study to prospectively measure the effect of a smoking ban on subclinical outcomes related to cardiovascular physiology. A major asset of this study is the quasi experimental setting that allowed comparing the effects in workers where a smoke free workplace was introduced to a control group without an exposure change. A further strength is that exposure data was collected at the same time as the health outcomes. A prospective study avoids the dangers of a possible recall bias and mixed linear models allow for within-subject clustering. By using the MoNIC badge, SHS exposure was directly quantified by measuring nicotine without using a surrogate measure such as airborne particulate matter.

Although exposure misclassification cannot be excluded, in particular for individuals of the control group without a workplace badge, the consistency of the results between the pre/post models with the exposure-response model suggests that exposure misclassification is unlikely to bias our results. Due to limited sample size we could not differentiate between the two follow-up examinations in our analysis but this should not have caused any bias. Recruitment of eligible participants was unexpectedly tedious as restaurant owners were worried about financial losses caused by the smoking ban, a concern that was shown to be baseless (36). The exposed control group was younger, physically more active and reported more asthma. This might have influenced the results. However, they are unlikely to explain the full pattern, since we have considered these factors in the exposure-response model. The pre/post model is mainly a within-subject comparison where group differences are less relevant.

Conclusions

This study indicates that introduction of smoke-free workplaces in hospitality venues substantially lowers cardiovascular risk factors in non-smoking hospitality workers and emphasizes the need for authorities worldwide to implement comprehensive policies in order to prevent adverse health effects.

Conflict of interest

The authors declare that they have no conflict of interest.

Ethics Statement

Ethical approval was obtained from the EKBB (Ethics committee of both cantons of Basel) and all participants signed an informed consent before every examination (Ref. No. EK 317/09).

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Table 5-1 Study population, Switzerland 2010/2011

		Intervention group (n=55)	Control group (n=23)	Supplementary group (n=14)	p-Value‡
Female sex		33 (60%)	13 (57%)	11 (79%)	0.37
Age (years)		42.2 (95% CI: 39.0-45.4)	31.8 (95% CI: 26.4-37.2)	46.8 (95% CI: 41.1-52.5)	0.001
BMI (kg/m^2)		26.0 (95% CI: 24.9-27.2)	25.0 (95% CI: 22.7-27.2)	25.0 (95% CI: 23.3-26.7)	0.23
Overweight (BMI>25)		28 (50.1 %)	11 (47.8 %)	5 (35.7 %)	0.60
Smoking status	Never-smokers	40 (72.7 %)	21 (91.3 %)	12 (85.7 %)	0.15
	Ex-smokers	15 (27.3 %)	2 (8.7 %)	2 (14.3 %)	
Self-reported asthma		4 (7.3 %)	8 (34.8 %)	1 (7.1)	0.01
Systolic blood pressure (mmHg)		125.0 (95% CI: 121.2-128.7)	122.3 (95% CI: 115.6-129.1)	128.6 (95% CI: 122.7-134.4)	0.16
Diastolic blood pressure (mmHg)		81.5 (95% CI: 78.8-84.1)	77.8 (95% CI: 73.3-82.3)	82.3 (95% CI: 77.9-86.6)	0.24
Hypertension#		15 (27.3 %)	11 (4.4 %)	4 (28.6 %)	0.07
Self-reported diabetes mellitus		0 (0 %)	0 (0 %)	0 (0 %)	
Coronary disease§		1 (1.8 %)	0 (0 %)	1 (7.1 %)	0.34
Betablocker intake		6 (10.9 %)	1 (4.4 %)	2 (14.3 %)	0.56
Allergic*		38 (69.1 %)	16 (69.6 %)	6 (42.9 %)	0.30

Self-reported physical activity†		19 (34.6 %)	16 (69.6 %)	10 (71.4 %)	0.02
Average workload (%)		93.8 (n=55)	100.0 (n=7)	84.3 (n=14)	0.20
Type of workplace	bar	5 (9.1 %)	2 (88.7 %)	0 (0 %)	0.007
	café	18 (32.7 %)	0 (0 %)	0 (0 %)	
	restaurant	32 (58.2 %)	5 (21.7 %)	14 (100 %)	
	other	0 (0 %)	16 (69.6 %)	0 (0 %)	
Pre-ban workplace exposure (cigarette equivalents/day)		2.56 (95% CI: 1.70-3.44)	2.07 (95% CI: 0.96-3.18)	0.12 (95% CI: 0.03-0.21)	
Post-ban workplace exposure (cigarette equivalents/day)		0.16 (95% CI: 0.13-0.20)	1.59 (95% CI: 0.67-2.50)	NA	

Values shown are arithmetic means at baseline except where indicated

‡ Kruskal Wallis Test for numerical data, Chi square for proportion
 # defined as positive if diastolic blood pressure>90 mmHg OR systolic blood pressure>140 mmHg
§ defined as: has taken medication for coronary heart disease during the past 7d
**reacted positively to at least one skin prick test*
†defined as: answered yes to: do you sweat at least once/week due to physical activity?

Table 5-2 Heart Rate Variability and Pulse Wave Velocity: pre/post model, Switzerland 2010/2011

		Pre-Ban					Post-Ban				
		Intervention Group		Control Group		p-Value#	Intervention Group		Control Group		p-Value‡
		n	**Geometric Mean (95% CI)**	**n**	**Geometric Mean (95% CI)**		**n**	**Geometric Mean (95% CI)**	**n**	**Geometric Mean (95% CI)**	
SDNN	unadjusted	53	42.1 (37.8-47.0)	21	48.0 (37.5-61.5)		84	46.2 (42.3-50.4)	19	41.4 (33.4-51.3)	
[ms]*	adjusted	53	42.4 (38.2-47.1)	21	43.6 (37.0-51.4)	0.79	84	47.6 (43.3-52.2)	19	38.6 (32.3-46.2)	0.02
RMSSD	unadjusted	53	28.9 (24.9-33.5)	21	36.2 (25.8-50.8)		84	32.5 (28.8-36.7)	19	31.1 (22.2-43.6)	
[ms]*	adjusted	53	30.5 (26.7-34.8)	21	29.7 (24.1-36.7)	0.86	84	34.2 (30.2-38.6)	19	26.7 (21.2-33.4)	0.04
LF/HF*	unadjusted	53	1.5 (1.2-1.9)	21	1.0 (0.6-1.6)		84	1.3 (1.1-1.5)	19	1.3 (0.8-2.0)	
	adjusted	53	1.4 (1.1-1.7)	21	1.2 (0.9-1.7)	0.48	84	1.2 (1.0-1.5)	19	1.6 (1.2-2.3)	0.01
HF [ms²]*	unadjusted	53	341.4 (240.8-483.8)	21	556.3 (265.3-1166.3)		84	450.4 (342.7-591.9)	19	377.8 (179.3-796.2)	
	adjusted	53	376 (280-505)	21	362 (226-582)	0.92	84	514 (390-677)	19	258 (155-430)	0.01
LF [ms²]*	unadjusted	53	522.6 (408.7-668.2)	21	555.9 (336.5-918.2)		84	558.1 (461.7-674.7)	19	458.8 (287.2- 732.7)	
	adjusted	53	535 (424-674)	21	444 (310-636)	0.39	84	605 (494-741)	19	395 (266-588)	0.28
Total Power	unadjusted	53	1797.2 (1439.4-2243.9)	21	2348.0 (1399.6-3939.0)		84	2188.8 (1832.1-2614.9)	19	1739.1 (1118.8-2703.2)	
[ms²]*	adjusted	53	1807 (1454-2247)	21	1951 (1387-2745)	0.73	84	2323 (1915-2819)	19	1517 (1042-2207)	0.02

PWV	unadjusted	52	11.2 (10.8-11.6)	19	9.8 (8.9-10.8)		83	10.8 (10.5-11.1)	18	9.8 (9.2-10.5)	
[m/s]**	adjusted	52	11.1 (10.8-11.4)	19	10.5 (10.1-11.0)	0.03	83	10.8 (10.5-11.1)	18	10.5 (10.0-11.0)	0.12
Systolic blood	unadjusted	55	124.3 (120.7-127.9)	23	121.3 (114.7-128.4)		85	123.4 (120.5-126.4)	19	124.3 (119.8-128.9)	
pressure [mmHg]§	adjusted	55	124.1 (120.7-127.5)	23	125.9 (120.4-131.4)	0.90	85	122.8 (119.5-126.1)	19	128.3 (122.3-134.3)	0.13

**Adjusted for age, sex, bmi and season*
***Adjusted for age, sex, bmi, systolic blood pressure, circadian rhythm and season*
§Adjusted for age, sex, bmi, season and asthma
#Covariate adjusted p-value for the baseline difference according to the mixed linear model
‡Covariate adjusted p-value for the intervention effect based on the interaction term of the mixed linear model

Table 5-3 Heart Rate Variability and Pulse Wave Velocity: Exposure-Response model, Switzerland 2010/2011

	Coefficient# (95% CI)	p-Value	Age coefficient‡ (95% CI)	p-Value
SDNN*	1.8 (-0.1 to 3.8)	0.069	-1.5 (-2.1 to -0.9)	<0.001
RMSSD*	2.3 (0.2 to 4.4)	0.031	-2.6 (-3.4 to -1.9)	<0.001
LF/HF*	-5.7 (-9.1 to -2.4)	0.001	3.2 (2.1 to 4.4)	<0.001
HF*	5.7 (0.9 to 10.2)	0.020	-5.9 (-7.5 to -4.2)	<0.001
LF*	0.6 (-4.1 to 5.1)	0.802	-2.9 (-4.2 to -1.7)	<0.001
Total Power*	4.1 (0.0 to 8.0)	0.051	-3.0 (-4.1 to -1.8)	<0.001
PWV**	-0.72 (-0.40 to -1.05)	<0.001	0.69 (0.54 to 0.85)	<0.001
Systolic blood pressure***	-0.07 (-0.32 to 0.47)	0.722	0.28 (0.13 to 0.43)	<0.001

#change in % per unit decrease in cigarette equivalents
‡change in % per 1y increase in age
**adjusted for age, sex, bmi and season*
***adjusted for age, sex, bmi, season, systolic blood pressure and circadian rhythm*
****Adjusted for age, sex, bmi, season and asthma*

References

1. Seo DC, Torabi MR. Reduced admissions for acute myocardial infarction associated with a public smoking ban: matched controlled study. Journal of drug education. 2007;37(3):217-26.

2. Sargent RP, Shepard RM, Glantz SA. Reduced incidence of admissions for myocardial infarction associated with public smoking ban: before and after study. BMJ. 2004;328(7446):977-80.

3. Bartecchi C, Alsever RN, Nevin-Woods C, Thomas WM, Estacio RO, Bartelson BB, et al. Reduction in the incidence of acute myocardial infarction associated with a citywide smoking ordinance. Circulation. 2006;114(14):1490-6.

4. Goodman PG, Haw S, Kabir Z, Clancy L. Are there health benefits associated with comprehensive smoke-free laws. International journal of public health. 2009;54(6):367-78.

5. Pell JP, Haw S, Cobbe S, Newby DE, Pell AC, Fischbacher C, et al. Smoke-free legislation and hospitalizations for acute coronary syndrome. The New England journal of medicine. 2008;359(5):482-91.

6. Tan CE, Glantz SA. Association between smoke-free legislation and hospitalizations for cardiac, cerebrovascular, and respiratory diseases: a meta-analysis. Circulation. 2012;126(18):2177-83.

7. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. European heart journal. 1996;17(3):354-81.

8. Felber Dietrich D, Schindler C, Schwartz J, Barthelemy JC, Tschopp JM, Roche F, et al. Heart rate variability in an ageing population and its association with lifestyle and cardiovascular risk factors: results of the SAPALDIA study. Europace : European pacing, arrhythmias, and cardiac electrophysiology : journal of the working groups on cardiac pacing, arrhythmias, and cardiac cellular electrophysiology of the European Society of Cardiology. 2006;8(7):521-9.

9. Pope CA, 3rd, Eatough DJ, Gold DR, Pang Y, Nielsen KR, Nath P, et al. Acute exposure to environmental tobacco smoke and heart rate variability. Environmental health perspectives. 2001;109(7):711-6.

10. Felber Dietrich D, Schwartz J, Schindler C, Gaspoz JM, Barthelemy JC, Tschopp JM, et al. Effects of passive smoking on heart rate variability, heart rate and blood pressure: an observational study. International journal of epidemiology. 2007;36(4):834-40.

11. Bilchick KC, Berger RD. Heart rate variability. Journal of cardiovascular electrophysiology. 2006;17(6):691-4.

12. Chen CY, Chow D, Chiamvimonvat N, Glatter KA, Li N, He Y, et al. Short-term secondhand smoke exposure decreases heart rate variability and increases arrhythmia susceptibility in mice. American journal of physiology Heart and circulatory physiology. 2008;295(2):H632-9.

13. Vlachopoulos C, Aznaouridis K, Stefanadis C. Prediction of cardiovascular events and all-cause mortality with arterial stiffness: a systematic review and meta-analysis. Journal of the American College of Cardiology. 2010;55(13):1318-27.

14. McEniery CM, Cockcroft JR. Does arterial stiffness predict atherosclerotic coronary events? Advances in cardiology. 2007;44:160-72.

15. Vlachopoulos C, Aznaouridis K, Terentes-Printzios D, Ioakeimidis N, Stefanadis C. Prediction of cardiovascular events and all-cause mortality with brachial-ankle elasticity index: a systematic review and meta-analysis. Hypertension. 2012;60(2):556-62.

16. Barnoya J, Glantz SA. Cardiovascular effects of secondhand smoke: nearly as large as smoking. Circulation. 2005;111(20):2684-98.

17. Kubozono T, Miyata M, Ueyama K, Hamasaki S, Kusano K, Kubozono O, et al. Acute and chronic effects of smoking on arterial stiffness. Circulation journal : official journal of the Japanese Circulation Society. 2011;75(3):698-702.

18. Hill MA. HM Practical - Blood Vessel Histology: Retrieved July 26, 2013, from http://php.med.unsw.edu.au/embryology/index.php?title=HM_Practical_-_Blood_Vessel_Histology; 2013.

19. Yu-Jie W, Hui-Liang L, Bing L, Lu Z, Zhi-Geng J. Impact of smoking and smoking cessation on arterial stiffness in healthy participants. Angiology. 2013;64(4):273-80.

20. Tomiyama H, Hashimoto H, Tanaka H, Matsumoto C, Odaira M, Yamada J, et al. Continuous smoking and progression of arterial stiffening: a prospective study. Journal of the American College of Cardiology. 2010;55(18):1979-87.

21. Roosli M, Rajkumar S. How long is the yardstick for smoking bans in Switzerland? International journal of public health. 2013;58(6):797-8.

22. Huynh CK, Moix J, Dubuis A. Development and application of the passive smoking monitor MoNIC. Revue Médicale Suisse. 2008;4(144):430-3.

23. Durham AD, Bergier S, Morisod X, Locatelli I, Zellweger JP, Huynh CK, et al. Improved health of hospitality workers after a Swiss cantonal smoking ban. Swiss medical weekly. 2011;141:w13317.

24. Rajkumar S, Huynh CK, Bauer GF, Hoffmann S, Roosli M. Impact of a smoking ban in hospitality venues on second hand smoke exposure: a comparison of exposure assessment methods. BMC public health. 2013;13:536.

25. Secondhand Smoke Exposure and Cardiovascular Effects: Making Sense of the Evidence. Practice BoPHaPH, editor: The National Academies Press; 2010.

26. Zhang J, Fang SC, Mittleman MA, Christiani DC, Cavallari JM. Secondhand tobacco smoke exposure and heart rate variability and inflammation among non-smoking construction workers: a repeated measures study. Environmental health : a global access science source. 2013;12(1):83.

27. Wilson MD, McGlothlin JD, Rosenthal FS, Black DR, Zimmerman NJ, Bridges CD. Ergonomics. The effect of occupational exposure to environmental tobacco smoke on the heart rate variability of bar and restaurant workers. Journal of occupational and environmental hygiene. 2010;7(7):D44-9.

28. Barutcu I, Esen AM, Kaya D, Turkmen M, Karakaya O, Melek M, et al. Cigarette smoking and heart rate variability: dynamic influence of parasympathetic and sympathetic maneuvers. Annals of noninvasive electrocardiology : the official journal of the International Society for Holter and Noninvasive Electrocardiology, Inc. 2005;10(3):324-9.

29. Levin FR, Levin HR, Nagoshi C. Autonomic functioning and cigarette smoking: heart rate spectral analysis. Biological psychiatry. 1992;31(6):639-43.

30. Hayano J, Yamada M, Sakakibara Y, Fujinami T, Yokoyama K, Watanabe Y, et al. Short- and long-term effects of cigarette smoking on heart rate variability. The American journal of cardiology. 1990;65(1):84-8.

31. Kageyama T, Nishikido N, Honda Y, Kurokawa Y, Imai H, Kobayashi T, et al. Effects of obesity, current smoking status, and alcohol consumption on heart rate variability in male white-collar workers. International archives of occupational and environmental health. 1997;69(6):447-54.

32. Murata K, Landrigan PJ, Araki S. Effects of age, heart rate, gender, tobacco and alcohol ingestion on R-R interval variability in human ECG. Journal of the autonomic nervous system. 1992;37(3):199-206.

33. Yotsukura M, Koide Y, Fujii K, Tomono Y, Katayama A, Ando H, et al. Heart rate variability during the first month of smoking cessation. American heart journal. 1998;135(6 Pt 1):1004-9.

34. Minami J, Ishimitsu T, Matsuoka H. Effects of smoking cessation on blood pressure and heart rate variability in habitual smokers. Hypertension. 1999;33(1 Pt 2):586-90.

35. Dinas PC, Koutedakis Y, Flouris AD. Effects of active and passive tobacco cigarette smoking on heart rate variability. International journal of cardiology. 2013;163(2):109-15.

36. Schulz PJ, Hartung U, Fiordelli M. Effect of smoke-free legislation on Ticino gastronomy revenue. International journal of public health. 2012;57(6):861-6.

6 ARTICLE 3: The Effect of a Smoking Ban On Respiratory Health in Non-Smoking Hospitality Workers: A Prospective Cohort Study

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ABSTRACT

Objective. The aim of this study was to examine the effect of a smoking ban on lung function, fractional exhaled nitric oxide (FeNO) and respiratory symptoms in non-smoking hospitality workers.

Methods. Secondhand smoke (SHS) exposure at the workplace, spirometry and FeNO were measured in 92 non-smoking hospitality workers before as well as twice after a smoking ban.

Results. At baseline, SHS exposed hospitality workers had lung function values significantly below the population average. After the smoking ban, covariate adjusted odds ratio for cough was 0.59 (95% CI: 0.36-0.93) and for chronic bronchitis 0.75 (95% CI: 0.55-1.02) compared to the pre ban period.

Conclusions. The below average lung function prior to the smoking ban indicates chronic damages from long-term exposure. Respiratory symptoms such as cough significantly decreased within 12 months after the ban.

BACKGROUND

It has been established that both active and passive smoking are closely linked to progressive lung function decline (1, 2). Cross-sectional studies have observed significantly higher prevalences for respiratory symptoms such as cold, cough, phlegm and throat problems in persons exposed to SHS at the workplace (3-6). In the last decades, smoking bans for public places including hospitality venues were implemented in many countries all over the world and potential benefits on respiratory health were evaluated. Several longitudinal studies examined self-reported respiratory symptoms and lung function before and after a smoking ban. Some researchers found less respiratory symptoms in both non-smokers and smokers (7, 8) and could show that this reduction did not occur in the control group (8, 9). While respiratory symptoms are very consistently reported as declining (7, 8, 10, 11), findings on lung function outcomes are more variable. Two studies in bar workers reported significant improvements in Forced Vital Capacity (FVC), but not in Forced Expiratory Volume in 1 second (FEV_1) or Forced Expiratory Flow 25-75% ($FEF_{25-75\%}$) after two months (10) or one year (12) of smoking ban introduction. A study from the French part of Switzerland also observed significant improvements in FVC, most pronounced in women, non-smokers and persons above 35 years (13). Conversely, another study found a significant increase in FEV_1 in healthy and asthmatic bar workers within one month after ban implementation but did not report any findings on FVC or $FEF_{25-75\%}$ (11). A Swedish study did not observe any noteworthy improvements in lung function parameters after the smoking ban (14). A recent Swiss study reported a significant decrease in hospital admission for acute exacerbation of COPD after a smoking ban but no changes for asthma or pneumonia (15).

Fractional Exhaled Nitric Oxide (FeNO) is a marker of airway inflammation, that has been increasingly studied in the past 20 years (16). Measurement of FeNO is non-invasive and highly reproducible and can easily be performed online or offline (17). It has primarily been used to investigate and monitor asthma. Allergen exposure upregulates inducible NO synthase (iNOS) in the airway epithelial cells (16). Cigarette smoke is believed to downregulate iNOS via a potential negative feedback mechanism (18). Decreased FeNO levels have been observed in smoking asthmatics (19) as well as in non-atopic smokers (20) that rise after smoking cessation (21). The same mechanisms might reduce FeNO levels when being exposed to second hand smoke (SHS). However, empirical data is scarce and ambiguous. Although one study found decreased FeNO levels in non-smokers exposed to SHS (22), several studies reported the opposite in young children exposed to parental smoking (23, 24). This is the first study to look at the effects of SHS exposure elimination at the workplace on FeNO levels in non-smokers.

The implementation of a national smoking ban in Switzerland in May 2010 was used to set up a prospective, longitudinal study of non-smoking hospitality workers in three cantons: Zurich, Basel City and Basel County. The two aims of the study were i) to compare baseline spirometry values of SHS exposed hospitality workers to reference values from the literature and ii) to directly relate work-place SHS exposure in non-smoking hospitality workers before and 6-12 months after a smoking ban to their respiratory health.

METHODS

Study population

The study population consisted of 92 participants in total: 62 non-smoking hospitality workers, who had worked for at least 1 year in venues where smoking was either partially or completely allowed prior to the introduction of the smoking ban, 14 non-smoking hospitality workers who worked in a smoke-free environment at baseline, and 16 non-smokers who were regularly exposed to SHS without being employed in the hospitality sector. These additional 16 non-smokers were recruited in order to enlarge the sample size. All hospitality workers worked in a hospitality venue in one of the study cantons. Data were collected between March 2010 and December 2011.

In order to recruit hospitality workers, a list of hospitality venues in the cantons of Zurich, Basel City and Basel County was created using the digital Swiss phonebook from 2009. Each venue received a letter containing information about the study, with a request to distribute screening questionnaires to staff serving at tables or at the bar (waiting staff) and for air measurements to be performed by the study team. These letters were followed by phone calls and visits two weeks later.

Screening questionnaires were distributed to the waiting staff, to provide information on the eligibility criteria which were being between 18 and 65 years of age, working at least half-time, having worked for at least one year in the hospitality sector and having been a non-smoker for at least 5 years. Eligible study participants were invited to a health examination, which was carried out in one of the two study centres in Basel City and Zurich.

The non-hospitality workers were recruited by means of an online advertisement looking for non-smokers that were exposed to SHS on a regular basis, either privately or at work.

Health examinations

Ethical approval was obtained from the EKBB (Ethics committee of both cantons of Basel) and all participants signed an informed consent before every examination (Ref. No. EK 317/09).

A baseline examination was conducted within the 3 months prior to the introduction of the smoking ban. Subsequently, all study participants who were exposed to SHS at baseline were invited for two follow-up examinations at 3-6 months and 9-12 months after the smoking ban introduction.

The health examinations comprised cardiovascular and respiratory tests. Spirometry tests were performed using a portable EasyOne spirometer from ndd Medical Technologies and read out with the EasyWare software. Each participant had to wear a nose clip and was required to perform three successful measurements within a maximum of eight trials according to the ATS (American Thoracic Society) guidelines (25). For FVC and FEV_1 the single highest value of all tests was used for analysis, for $FEF_{25-75\%}$ and the FEV_1/FVC ratio the value from the best test (FVC + FEV_1=max.) was taken.

FeNO measurements were performed with a pressure controlled SIEVERS NOA 280 offline kit using a Mylar bag® to collect the exhaled breath following the ATS/ERS recommendations (26). Participants were asked to inhale through a mouthpiece attached to a NO-scrubber and then exhale against a set expiratory resistance maintaining a constant pressure of 12-16 mbar without wearing a mouthpiece. The constant pressure was achieved by visual feedback from an inline pressure gauge. The pressure range allowed maintaining a constant expiratory flow of 50 ml/sec. After five seconds the expiratory air was collected into a Mylar bag® until the bag was full. Ambient air was pumped into an additional bag to check for exceeding levels of ambient FeNO. The FeNO content was measured within twelve hours with an EcoMedics CLD 88 analyser using Spiroware 3.0. For data analysis the average of the two personal measurements was used.

Participants were defined as asthmatics if they reported having suffered from asthma at an adult age. Asthmatics currently on inhaled corticosteroids (ICS) were excluded from the analysis as ICS decrease FeNO levels (4 baseline and 6 follow-up observations). A skin prick test at baseline comparing the six most common allergens: birch, mixed grasses, alternaria, mugwort, cat hair and dermatophtgoides to a positive and a negative control was performed in each participant at baseline. Test solutions were obtained from Trimedal in Dietlikon, Switzerland. Participants were considered sensitized if they showed a minimal wheal size of 3mm to at least one tested allergen.

Interviews

Respiratory and allergy symptoms were assessed during the health examinations in a computer-based interview adapted from a standardized questionnaire previously evaluated in the Swiss population (27). We asked about respiratory and allergy symptoms in the last three to twelve months respectively. Asthmatic symptoms were defined as breathlessness, wheezing or chest tightness. A person was considered to have chronic bronchitis if he/she stated to suffer from cough or phlegm (27). Participants were counted as positive for hay fever if they had suffered from symptoms in the present or the previous year. Rhinitis was defined as sneezing and a running nose during the past twelve months without having a cold or influenza. Eczema was considered to be present if participants had ever had an itchy skin rash in areas typical for eczema.

Exposure measurements

SHS was objectively measured using newly developed MoNIC passive sampling badges as previously described (28). MoNIC badges are glass fibre filters that are washed with distilled water, methanol and CH_2Cl_2, impregnated with 5mg sodium bisulphate per filter and placed in an air-tight plastic case. Badges were always transported between study centres, participants, and the laboratory in these air-tight cases. The amount of nicotine on the badge was determined by gas chromatography and used to calculate the number of passively smoked cigarettes/day (CE/d) assuming a nicotine content of 0.2 mg/cigarette and an average ventilation rate of 10 L/min (13, 29).

In the hospitality venues that agreed to participate, at least one MoNIC badge was placed for one week, near the bar where waiting personnel spend much of their working time (hereafter referred to as "workplace badge"). We calculated for each hospitality worker a time-weighted average workplace exposure (28) by multiplying their average workplace concentration by their workload (in percentage of full time equivalent) and by 0.6, which represents time present at the work place, includes holidays and considers the fact that nicotine levels decrease when a venue is unattended (28). For non-hospitality workers average SHS exposure was obtained from a personal badge that participants wore on themselves on a typical day.

Data analysis

In order to estimate the long-term consequences of working in SHS exposed hospitality venues on lung function, we calculated for each study participant, who was exposed to SHS at baseline, age, gender and height adjusted percentage FEV_1 and FVC values from reference values for a non-smoking Swiss population sample (30).

By considering the within subject correlation, mixed linear random intercept regression models were used to relate respiratory parameters to work place SHS exposure at the time of each health examination (baseline and follow-ups). Lung function models were calculated adjusting for age, sex, height, BMI (linear), asthma (binary), season (cosine function), and device number (categorical). FeNO levels were log-transformed and back-transformed model coefficients are reported. FeNO models were adjusted for age, sex, allergy (binary), season (cosine function) and time of day (cosine function). The cosine function for time of day variations assigned the value of 0 to 12pm and 1 to 12am and for seasonal variations the value of 0 to 1 July and 1 to 1 January. Respiratory symptoms were evaluated by means of GEE (Generalized Estimated Equation) regression models adjusted for age, sex, season and systolic blood pressure.

Data were analysed using Stata 10.1 and Stata 12.0 (StataCorp LP, College Station, TX).

RESULTS

Our study sample comprised 92 participants (Table 6-1) with no one suffering from COPD. Thereof 23 individuals were exposed throughout the study, 55 were only exposed at baseline, but not anymore at follow-up and 14 were never exposed. At baseline average exposure of the 14 study participants who were never exposed to SHS was 0.1 (95% CI: 0.0-0.2) cigarette equivalents per day (CE/d) whereas exposure in the 78 SHS exposed study participants, was 2.4 (95% CI: 1.7 to 3.1) CE/d. Of these 78 participants, 55 were not anymore exposed at follow-up and their

SHS exposure decreased to 0.2 (95% CI: 0.1 to 0.2) CE/d while staying at 1.6 (95% CI: 0.7-2.5) CE/d for the 23 participants who were still exposed at the follow-up examinations.

From the lung function analyses, 20 observations were excluded due to insufficient quality (n=16), technical problems (n=1) or insufficient cooperation (n=3). For FeNO, ten baseline and one follow-up measurement had to be excluded from analysis due to technical problems.

At baseline, age, sex and height specific fitted FVC and FEV_1 curves of our sample of non-smoking SHS exposed hospitality workers was below the population reference curve (30) for most of the age range in men and women (Figure 6-1). The difference was most pronounced for FEV_1 in women (Table 6-2). However, longitudinal exposure-response models did not indicate an association between lung function parameters and SHS exposure (Table 6-3). FVC showed a decreasing tendency with increasing exposure but this association was not significant. When using exposure measures from personal badges that took into account private exposure no association could be observed either (data not shown).

Average FeNO levels of non-asthmatic study participants was 11.3 (95% CI: 10.3 to 12.5) ppb and of asthmatic study participants 14.3 (95% CI: 8.6 to 20.0) ppb. FeNO was not related to SHS exposure in the longitudinal exposure-response model (Table 6-3). Other co-variables that were included into the model such as smoking history, former smoking status, physical activity or childhood SHS exposure did not show any association either and were therefore excluded from the final models. However, FeNO values are 36.1% (95%-CI: 6.9 to 73.2) higher on 1 January compared to 1 July (p=0.01) according to the cosine seasonality function in the model.

The exposure-response model yielded an odds ratio of 1.25 (95% CI: 1.03-1.53) per CE/d increase in SHS exposure for cough and 1.13 (95% CI: 0.99-1.28) for chronic bronchitis (Table 6-4). Since the average SHS exposure reduction from the smoking ban was 2.4 CE/d, these odds ratios translate in a smoking ban OR of 0.59 (95% CI:

0.36-0.93) for cough and 0.75 (95% CI: 0.55-1.02) for chronic bronchitis. We found no clear associations for phlegm and asthma symptoms.

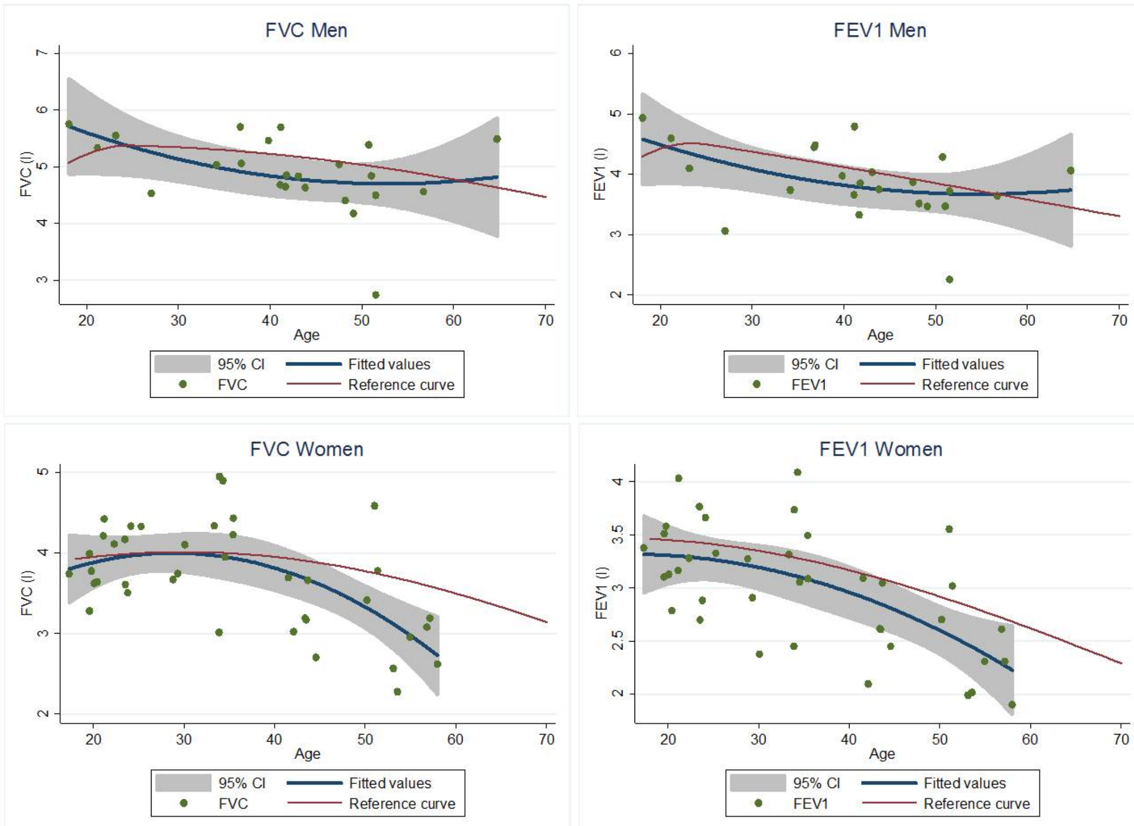

Figure 6-1 Fitted FVC and FEV1 at baseline for men (n=23) and women (n=39) adjusted for age and height in comparison to reference curves

DISCUSSION

In our study population, of SHS exposed non-smoking hospitality workers, we observed significantly below-average values of FVC and FEV_1 before implementation of a smoking ban. We found indications that introducing a smoke-free workplace reduced cough and chronic bronchitis but not lung function parameters or FeNO.

In line with other smoking ban studies in hospitality workers (10-12) below average lung function was observed in the study participants who were exposed to SHS at baseline and had worked under such circumstances for at least one year but mostly substantially longer. On average our participants had worked in a SHS exposed environment for 8.5 years ranging from 1 to 33 years. In women the reduction of the lung function compared to the reference curve increases with age. For men, this pattern was impeded by one observation with exceptionally good lung function at high age. This pattern, although based on few observations, suggests a continuous degradation of the lung function with increasing exposure time. In contrast to our hypothesis that lung function would increase during the study, we did not observe any improvement in lung function 6 to 12 months after the introduction of the smoke-free workplaces. This corresponds to the findings of a Swedish study looking at 71 smokers and non-smokers that did not find any significant changes in spirometry one year after implementation of a smoking ban (14) but contradicts three other studies that observed significant improvements in FVC of bar workers after eight weeks (10) to one year (12, 13). According to our exposure-response model FVC increased by 0.16 ppb per daily cigarette equivalent decrease in SHS exposure, which was not statistically significant (p=0.26) (Table 6-3).

This non-significance could be explained by the relatively small exposure reduction of 2.40 CE/d on average from before to after the ban. Low exposure levels may be explained by the fact that most of our study subjects worked in restaurants that served food. Our measurements performed in bars yielded much higher SHS levels but waiters there were mostly active smokers and/or unwilling to participate in the study. All previous studies reporting significant improvements in FVC or FEV_1 looked at bar workers that presumably experienced a sharper decline in exposure (10-12).

To the best of our knowledge this is the first study to prospectively measure the effect of a smoking ban on FeNO. We hypothesized that the introduction of smoke-free work places would lead to an increase in FeNO as has been observed in a smoking cessation study (21) but we did not observe an association between SHS exposure and FeNO levels in the exposure response analysis. Different developments in heavily and lightly SHS exposed persons regarding FeNO, as proposed by Malinovschi et al. (31) for heavy and light smokers could explain this. The interacting effects of SHS (32) and asthma (33, 34) on FeNO levels is complex and not yet fully understood. In addition to allergic inflammation further mechanisms may be involved in FeNO synthesis as indicated by the higher fluctuation observed in asthmatics in our study. So far only 11-30% of the variance of FeNO levels is explained by anthropometric characteristics compared to spirometry where 60-75% of the variation is explained (16). This is mainly because measurement techniques and the selected influencing factors differ between studies.

Research on the effect of active smoking on FeNO is fairly consistent with smokers showing reduced levels (17, 21, 22). Interestingly our observed FeNO values were also at the lower end or even below the range of population based reference FeNO values that have been published (35, 36) although these cover a fairly wide range. Dressel et al. (35) measured values with a geometric mean of 19.6 ÷ 1.92 ppb in a sample of 897 women with an average age of 34.5 ÷ 13 years and a 24.3% smoking prevalence. Matsunaga et al. (36) reports mean values of 16.9 (95%-CI: 6.5 to 35.0) ppb for a non-smoking Japanese adult population of 240. Our observed low levels may be the consequence of long term SHS exposure similar to the reduced FeNO levels of smokers.

We also measured heart rate variability and pulse wave velocity in the same study and reported these findings elsewhere (37). We found significant improvements in these cardiovascular parameters after the smoking ban introduction. This suggests that cardiovascular indicators react more sensitively within the first 12 months after a substantial SHS exposure reduction than respiratory markers.

A major asset of this study is the prospective design with repeated health examinations. The prospective design avoids recall bias in directly measured parameters – limiting this potential bias to self-reported respiratory symptoms. A further strength is that exposure data was collected at the same time as the health outcomes. By using the MoNIC badge, nicotine exposure was directly quantified without using a surrogate measure such as airborne particulate matter. A limitation of the study is the small sample size. It was particularly difficult to find SHS exposed non-smoking hospitality workers and we were therefore forced to include some non-hospitality workers. Potential bias from this recruitment strategy was minimized by carefully checking all relevant confounding factors in the data analysis.

CONCLUSIONS

In our study sample, of non-smoking hospitality workers, lung function was below the average population before implementation of the smoking ban and did not change within one year in relation to a smoking ban implementation. However, we found indications that cough and chronic bronchitis occurred less frequently after the smoking ban. These results indicate that damages from SHS to the respiratory system recover very slowly if at all and emphasize the need for a comprehensive smoking ban to avoid reduced lung function in non-smokers due to SHS at the work place.

List of Abbreviations

CE/d: cigarette equivalents/day

$FEF_{25-75\%}$: Forced Expiratory Flow between 25 and 75%

FeNO: Fractional exhaled Nitric Oxide

FEV_1: Forced Expiratory Volume in the first second

FVC: Forced Vital Capacity

ICS: inhaled corticosteroids

iNOS: inducible NO synthase

MoNIC: Monitor of Nicotine

SHS: Secondhand Smoke

Conflicts of Interest and Source of Funding

The authors declare that they have no conflict of interest.
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Table 6-1 Characteristics of the study population (n=92)

Female sex		57 (62%)
Age (years)		40.3 (95% CI: 37.6 to 43.0)
BMI (kg/m^2)		25.6 (95% CI: 24.7 to 26.5)
Smoking status	Never-smokers	67 (72.8 %)
	Ex-smokers	25 (27.2 %)
Self-reported physical activity†		45 (48.9 %)
Respiratory Symptoms		
Bronchitis symptoms	cough	27 (29.4 %)
	phlegm	11 (12.0 %)
Chronic bronchitis		2 (2.2 %)
Asthma symptoms		24 (26.1 %)
Allergy Symptoms	Hay fever	21 (22.8 %)
	Rhinitis	30 (32.6 %)
	Eczema	6 (6.5 %)
Comorbidities		
Self-reported bronchial asthma		13 (14.1 %)
Allergic*		60 (65.2 %)
Workplace and exposure (n=76)		
Average workload (%)		92.6 (95% CI: 88.8 to 96.4)
Type of workplace	bar	7 (9.2 %)

	café	18 (23.7 %)
	restaurant	51 (67.1 %)
Exposed throughout the study		23 (25.0 %)
Exposed at baseline, not exposed anymore at follow-up		55 (59.8 %)
Never exposed		14 (15.2 %)

Values shown are arithmetic means at baseline except where indicated

†defined as: answered yes to: do you sweat at least once/week due to physical activity?

*reacted positively to at least one skin prick test

Table 6-2 FVC and FEV1 baseline measurements of exposed participants in comparison to reference values [29]

	All (n=62)	**Women (n=39)**	**Men (n=23)**
FVC (in % of reference value)	93.1 (90.2 to 95.9)	93.3 (89.7 to 97.0)	92.6 (87.8 to 97.5)
FEV_1 (in % of reference value)	92.4 (89.4 to 95.4)	91.9 (88.2 to 95.6)	93.2 (87.7 to 98.6)

Table 6-3 Multivariable exposure-response models relating SHS exposure at the workplace to respiratory outcomes

	Coefficient (change / unit increase in cigarette equivalents) (95% CI)	p-Value
FEV_1 (l/s)*	0.04 (-0.28 to 0.37)	0.79
FVC (l)*	-0.16 (-0.64 to 0.11)	0.26
$FEF_{25-75\%}$ (l/s)*	0.31 (-0.62 to 1.25)	0.51
FEV_1/FVC ratio *	0.16 (-0.09 to 0.41)	0.20
FeNO (ppb)§	0.8 (-2.2 to 3.9)	0.62

*Adjusted for age, sex, height, BMI, asthma, season, device

§Adjusted for age, sex, allergy, seasonality, time of day

[1]From the lung function analyses, 20 observations were excluded due to insufficient quality (n=16), technical problems (n=1) or insufficient cooperation (n=3). For FeNO, eleven measurements had to be excluded from analysis due to technical problems.

Table 6-4 Multivariable logistic regression models relating SHS exposure at the workplace to self-reported respiratory symptoms

	OR per unit increase in cigarette equivalents (95% CI)	p-value
Cough	1.25 (1.03 to 1.53)	0.03
Phlegm	0.98 (0.89 to 1.09)	0.76
Chronic bronchitis	1.13 (0.99 to 1.28)	0.07
Asthma symptoms	1.11 (0.96 to 1.29)	0.16

References

1. Downs SH, Brandli O, Zellweger JP, Schindler C, Kunzli N, Gerbase MW, et al. Accelerated decline in lung function in smoking women with airway obstruction: SAPALDIA 2 cohort study. Respiratory research. 2005;6:45.

2. Xu X, Dockery DW, Ware JH, Speizer FE, Ferris BG, Jr. Effects of cigarette smoking on rate of loss of pulmonary function in adults: a longitudinal assessment. The American review of respiratory disease. 1992;146(5 Pt 1):1345-8.

3. Ho SY, Lam TH, Chung SF, Lam TP. Cross-sectional and prospective associations between passive smoking and respiratory symptoms at the workplace. Annals of epidemiology. 2007;17(2):126-31.

4. Lam TH, Ho LM, Hedley AJ, Adab P, Fielding R, McGhee SM, et al. Environmental tobacco smoke exposure among police officers in Hong Kong. JAMA : the journal of the American Medical Association. 2000;284(6):756-63.

5. Minov J, Karadzinska-Bislimovska J, Vasilevska K, Risteska-Kuc S, Stoleski S. Effects of passive smoking at work on respiratory symptoms, lung function, and bronchial responsiveness in never-smoking office cleaning women. Arhiv za higijenu rada i toksikologiju. 2009;60(3):327-34.

6. White JR, Froeb HF, Kulik JA. Respiratory illness in nonsmokers chronically exposed to tobacco smoke in the work place. Chest. 1991;100(1):39-43.

7. Ayres JG, Semple S, MacCalman L, Dempsey S, Hilton S, Hurley JF, et al. Bar workers' health and environmental tobacco smoke exposure (BHETSE): symptomatic improvement in bar staff following smoke-free legislation in Scotland. Occupational and environmental medicine. 2009;66(5):339-46.

8. Fernandez E, Fu M, Pascual JA, Lopez MJ, Perez-Rios M, Schiaffino A, et al. Impact of the Spanish smoking law on exposure to second-hand smoke and respiratory health in hospitality workers: a cohort study. PloS one. 2009;4(1):e4244.

9. Fahim AE, El-Prince M. Passive Smoking, Pulmonary Function and Bronchial Hyper-responsiveness among Indoor Sanitary Workers. Industrial health. 2012.

10. Eisner MD, Smith AK, Blanc PD. Bartenders' respiratory health after establishment of smoke-free bars and taverns. JAMA : the journal of the American Medical Association. 1998;280(22):1909-14.

11. Menzies D, Nair A, Williamson PA, Schembri S, Al-Khairalla MZ, Barnes M, et al. Respiratory symptoms, pulmonary function, and markers of inflammation among bar workers before and after a legislative ban on smoking in public places. JAMA : the journal of the American Medical Association. 2006;296(14):1742-8.

12. Goodman P, Agnew M, McCaffrey M, Paul G, Clancy L. Effects of the Irish smoking ban on respiratory health of bar workers and air quality in Dublin pubs. American journal of respiratory and critical care medicine. 2007;175(8):840-5.

13. Durham AD, Bergier S, Morisod X, Locatelli I, Zellweger JP, Huynh CK, et al. Improved health of hospitality workers after a Swiss cantonal smoking ban. Swiss medical weekly. 2011;141:w13317.

14. Larsson M, Boethius G, Axelsson S, Montgomery SM. Exposure to environmental tobacco smoke and health effects among hospitality workers in Sweden--before and after the implementation of a smoke-free law. Scandinavian journal of work, environment & health. 2008;34(4):267-77.

15. Humair JP, Garin N, Gerstel E, Carballo S, Carballo D, Keller PF, et al. Acute respiratory and cardiovascular admissions after a public smoking ban in geneva, Switzerland. PloS one. 2014;9(3):e90417.

16. Alving K, Malinovschi A. Chapter 1. Basic aspects of exhaled nitric oxide. 2010.

17. Kharitonov SA, Gonio F, Kelly C, Meah S, Barnes PJ. Reproducibility of exhaled nitric oxide measurements in healthy and asthmatic adults and children. The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology. 2003;21(3):433-8.

18. Hoyt JC, Robbins RA, Habib M, Springall DR, Buttery LD, Polak JM, et al. Cigarette smoke decreases inducible nitric oxide synthase in lung epithelial cells. Experimental lung research. 2003;29(1):17-28.

19. Horvath I, Donnelly LE, Kiss A, Balint B, Kharitonov SA, Barnes PJ. Exhaled nitric oxide and hydrogen peroxide concentrations in asthmatic smokers. Respiration; international review of thoracic diseases. 2004;71(5):463-8.

20. Kharitonov SA, Robbins RA, Yates D, Keatings V, Barnes PJ. Acute and chronic effects of cigarette smoking on exhaled nitric oxide. American journal of respiratory and critical care medicine. 1995;152(2):609-12.

21. Robbins RA, Millatmal T, Lassi K, Rennard S, Daughton D. Smoking cessation is associated with an increase in exhaled nitric oxide. Chest. 1997;112(2):313-8.

22. Nadif R, Matran R, Maccario J, Bechet M, Le Moual N, Scheinmann P, et al. Passive and active smoking and exhaled nitric oxide levels according to asthma and atopy in adults. Annals of allergy, asthma & immunology : official publication of the American College of Allergy, Asthma, & Immunology. 2010;104(5):385-93.

23. Franklin PJ, Turner S, Mutch R, Stick SM. Parental smoking increases exhaled nitric oxide in young children. The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology. 2006;28(4):730-3.

24. Frey U, Kuehni C, Roiha H, Cernelc M, Reinmann B, Wildhaber JH, et al. Maternal atopic disease modifies effects of prenatal risk factors on exhaled nitric oxide in infants. American journal of respiratory and critical care medicine. 2004;170(3):260-5.

25. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology. 2005;26(2):319-38.

26. ATS/ERS recommendations for standardized procedures for the online and offline measurement of exhaled lower respiratory nitric oxide and nasal nitric oxide. American journal of respiratory and critical care medicine. 2005;171(8):912-30.

27. Sistek D, Tschopp JM, Schindler C, Brutsche M, Ackermann-Liebrich U, Perruchoud AP, et al. Clinical diagnosis of current asthma: predictive value of respiratory symptoms in the SAPALDIA study. Swiss Study on Air Pollution and Lung Diseases in Adults. The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology. 2001;17(2):214-9.

28. Rajkumar S, Huynh CK, Bauer GF, Hoffmann S, Roosli M. Impact of a smoking ban in hospitality venues on second hand smoke exposure: a comparison of exposure assessment methods. BMC public health. 2013;13:536.

29. Huynh CK, Moix J, Dubuis A. [Development and application of the passive smoking monitor MoNIC]. Revue Médicale Suisse. 2008;4(144):430-3.

30. Brandli O, Schindler C, Kunzli N, Keller R, Perruchoud AP. Lung function in healthy never smoking adults: reference values and lower limits of normal of a Swiss population. Thorax. 1996;51(3):277-83.

31. Malinovschi A, Janson C, Hogman M, Rolla G, Toren K, Norback D, et al. Bronchial responsiveness is related to increased exhaled NO (FE(NO)) in non-smokers and decreased FE(NO) in smokers. PloS one. 2012;7(4):e35725.

32. Yates DH, Breen H, Thomas PS. Passive smoke inhalation decreases exhaled nitric oxide in normal subjects. American journal of respiratory and critical care medicine. 2001;164(6):1043-6.

33. de la Riva-Velasco E, Krishnan S, Dozor AJ. Relationship between exhaled nitric oxide and exposure to low-level environmental tobacco smoke in children with asthma on inhaled corticosteroids. The Journal of asthma : official journal of the Association for the Care of Asthma. 2012;49(7):673-8.

34. Laoudi Y, Nikasinovic L, Sahraoui F, Grimfeld A, Momas I, Just J. Passive smoking is a major determinant of exhaled nitric oxide levels in allergic asthmatic children. Allergy. 2010;65(4):491-7.

35. Dressel H, de la Motte D, Reichert J, Ochmann U, Petru R, Angerer P, et al. Exhaled nitric oxide: independent effects of atopy, smoking, respiratory tract infection, gender and height. Respiratory medicine. 2008;102(7):962-9.

36. Matsunaga K, Hirano T, Kawayama T, Tsuburai T, Nagase H, Aizawa H, et al. Reference ranges for exhaled nitric oxide fraction in healthy Japanese adult population. Allergology international : official journal of the Japanese Society of Allergology. 2010;59(4):363-7.

37. Rajkumar S, Schmidt-Trucksaess A, Wellenius GA, Bauer GF, Huynh CK, Moeller A, et al. The effect of workplace smoking bans on heart rate variability and pulse wave velocity of non-smoking hospitality workers International Journal of Public Health. 2014.

30. Dressel H, de la Motte D, Reichert J, Ochmann U, Petru R, Angerer P, et al. Exhaled nitric oxide: independent effects of atopy, smoking, respiratory tract infection, gender and height. Respiratory medicine. 2008 Jul;102(7):962-9. PubMed PMID: 18396030. Epub 2008/04/09. eng.

31. Karrasch S, Ernst K, Behr J, Heinrich J, Huber RM, Nowak D, et al. Exhaled nitric oxide and influencing factors in a random population sample. Respiratory medicine. 2011 May;105(5):713-8. PubMed PMID: 21146387. Epub 2010/12/15. eng.

7 ARTICLE 4: Evaluation of implementation, compliance and acceptance of partial smoking bans among Swiss hospitality workers before and after the Swiss Tobacco Control Act

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ABSTRACT

Background. The WHO recommends uniform comprehensive smoking bans in public places. In Switzerland, regulations differ between various areas and are mostly incomplete for hospitality venues. As ambiguous regulations offer more leeway for implementation, we evaluated the Swiss regulations with respect to their effects on implementation, acceptance and compliance among hospitality workers.

Methods. In our longitudinal study, a standardized, self-administered questionnaire was mailed to a sample of 185 hospitality workers before and 4-6 month after the smoking ban came into effect. The matched longitudinal sample comprised 71 participants (repeated response rate 38.4%). We developed a seven-item acceptance scale. Logistic regressions were performed to explore the factors associated with acceptance.

Results. Acceptance of smoking bans was influenced by smoking status and perceived annoyance with second-hand smoke in private. Although not statistically significant (p=0.09), we found some indications that post ban acceptance increased in an area with strict regulations whereas it decreased in two areas with less stringent regulations.

Conclusions. Tobacco bans in Swiss hospitality venues are still in a period of consolidation. The incomplete nature of the law may also have had a negative impact on the development of greater acceptance.

Keywords: Environmental Tobacco Smoke, Implementation Research, Workplace Health Promotion, Second Hand Smoke, Acceptance

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INTRODUCTION

Smoking policies, such as smoking restrictions in public areas, aim 1) to reduce second hand smoke (SHS) for the purpose of protecting non-smokers, 2) to reduce tobacco consumption among smokers, and 3) to encourage smoking cessation (1). Thus, most effectiveness studies dealing with the impact of smoking bans focus either on medical issues, SHS exposure or changes in smoking behaviour (2-5). However, implementing a new regulation such as a smoking ban can only succeed if the target group accepts and complies with the new rule (5-8). This particularly applies to situations where partial bans allow for a variation in the degree of implementation, as is the case in Switzerland. After intense public debate, and disregarding the WHO recommendation for total smoking bans, the Swiss Federal Law on protection from SHS partially banned smoking in closed public spaces, including hospitality venues, in May 2010. Small bars and restaurants up to 80 m2 remain open to smokers if they are marked on the outside as smoking establishments and if the staff have agreed to work there. Larger venues have the option of providing designated smoking rooms with ventilation. The cantons – administrative zones in Switzerland - are allowed to tighten these regulations. As a consequence, numerous regulations with different exceptions have been introduced in various cantons in Switzerland.

This situation raises the question as to the role of psychosocial factors such as acceptance and compliance in the implementation of smoking regulations. The few available research results on these issues are inconsistent due to heterogeneous concepts and operationalizations. Borland et al. (2006) report high compliance with smoking bans and greater support for total smoking bans by a smoking sample from the general population (9). They assessed attitudes to smoking restriction, asking whether smoking should be allowed in some areas. Thomson and Wilson (2006) report increasing public support six months after implementation of the New Zealand act, measuring attitudes to workers' rights to smoke-free workplaces and support for smoke-free hospitality venues (10). Other studies examined attitudes towards smoking regulations via an assessment of agreement vs. disagreement in a sample of workers in the metal industry (11) or approval vs. non-approval among the general population (12).

For our study, we define acceptance as the expression of consent to and support of the current smoking bans. Compliance covers how smoking bans are respected and evaluated by both employees and guests. Hospitality workers are of particular interest in this context: First, they are significantly more exposed to SHS compared to other occupational groups (13). Thus, they benefit the most from complete bans. Several studies addressed the impact of a complete smoking ban in hospitality venues on the health of the employees and found a consistent decrease of self-reported respiratory symptoms after reduction of the exposure (14-19). Second, they are confronted with the implementation of bans directly; as they have to enforce the bans among their guests. Thus, we assume acceptance of smoking bans among them as an important factor for a successful implementation of smoking restrictions.

Study aim and research questions

Our study aimed to evaluate the partial smoking regulations in hospitality venues introduced by the Swiss Tobacco Control Act with respect to the degree of their implementation, acceptance and compliance. The specific research questions were:

1) Did the smoking regulations in hospitality venues change after the ban came into effect?

2) Did compliance and acceptance of smoking regulations change after the ban?

3) Which factors are associated with acceptance of smoking regulations after the ban and are changes in acceptance related to the smoking regulation of the respective canton?

METHODS

In our longitudinal study, a standardized, self-administered questionnaire was mailed to a convenience sample of hospitality workers in the Swiss cantons of Basel

City (BS), Basel County (BL) and Zurich (ZH) before and after the law came into effect in May 2010.

Sample and response

From March to May 2010, study participants were recruited in their workplace either by site visits or letters sent to venues and by newspaper ads. These participants received the questionnaire by mail. Some participants also took part in a related medical study and completed the questionnaire by themselves during their medical examination or mailed it in afterwards. The follow-up survey was conducted four to six months after the law came into effect. Both surveys included reminder mailings to non-responders. The overall sample size was 185. In the first survey, 109 hospitality workers participated (response rate: 58,9%) and 83 in the second survey (response rate: 44,9%). The matched longitudinal sample consists of 71 participants (repeated response rate: 38,4%), working in 45 different venues.

Table 7-1 shows the response rates split up for the four participating cantons as well as the proportion of participants recruited during the medical exam. Accordingly, in the canton BL, the response rate was higher than in the other cantons as a larger proportion of the participants had been recruited during the medical exam where people could be better motivated to participate in the survey then through mailing the questionnaires.

Questionnaire

A self-administered questionnaire was developed on the basis of an extensive literature review. The content of the questionnaire was guided by the above listed research questions and by the availability of previously validated instruments. Items previously applied for oral interviews were adapted to a written survey. The questionnaire was conducted in German and contained 83 questions about current smoking regulations at the workplace and their compliance (5, 6, 20, 21). Acceptance of smoking bans was assessed in the form of progressive support for bans in restaurants and bars. Based on previous operationalizations, acceptance was determined by ten items on a six-point Likert-scale covering the range from complete agreement to no agreement at all plus a response option "I do not know" (22). These items covered the three aspects of acceptance previously identified in the literature: cognitive acceptance issues (personal relevance, knowledge), social factors (perception of non-smoking as a social norm and perception of relevant peers) and proactive acceptance (6, 23-26). Factors possibly associated with acceptance were self-reported exposure to SHS at work and in private (27) and perceived annoyance at the workplace and as a guest. Smoking status and behaviour (smokers only) were assessed according to the WHO definition (28). Cardio-respiratory health and allergies were surveyed with a selection of questions adapted from the Sapaldia II questionnaire (29).

Refinement of the acceptance scale

The newly developed acceptance scale was initially tested with all baseline data. For the ten-item acceptance scale, we found a Cronbach's α = .80 (N=100). The normally distributed ten-item scale correlates significantly with the independent item "attitude to the law" (r = .647). Nevertheless, three items reduced the reliability of the scale: perception of non-smoking as a social norm (Cronbach's α if item deleted = .83, N=103), information about cantonal smoking bans (Cronbach's α if item deleted = .85, N=105) and proactive acceptance (Cronbach's α if item deleted = .87, N=112). Since all three items have many missing values, they were excluded from further analyses. As exploratory factor analysis found no consistent factor structure, we used the one-factorial, normally distributed seven-item acceptance scale (Cronbach's α = .87, Table 7-2) for further analysis. To include as many cases as possible, we used a mean scale with at least six of seven valid items. Within our longitudinal sample (N=71), the seven-item acceptance scale yields a Cronbach's α = .85 at baseline and a Cronbach's α = .82 at follow-up.

Data analysis

Statistical analysis was performed using SPSS (Version 19.0.0, IBM). We applied the Chi^2 hypothesis test to compare baseline to follow-up. To explore which factors were associated with acceptance we applied logistic regression with follow-up data in a forward selection procedure. The final model contains apart from sex, age and smoking status perceived annoyance at the workplace and feeling annoyed as a guest in a hospitality venue as independent variables.

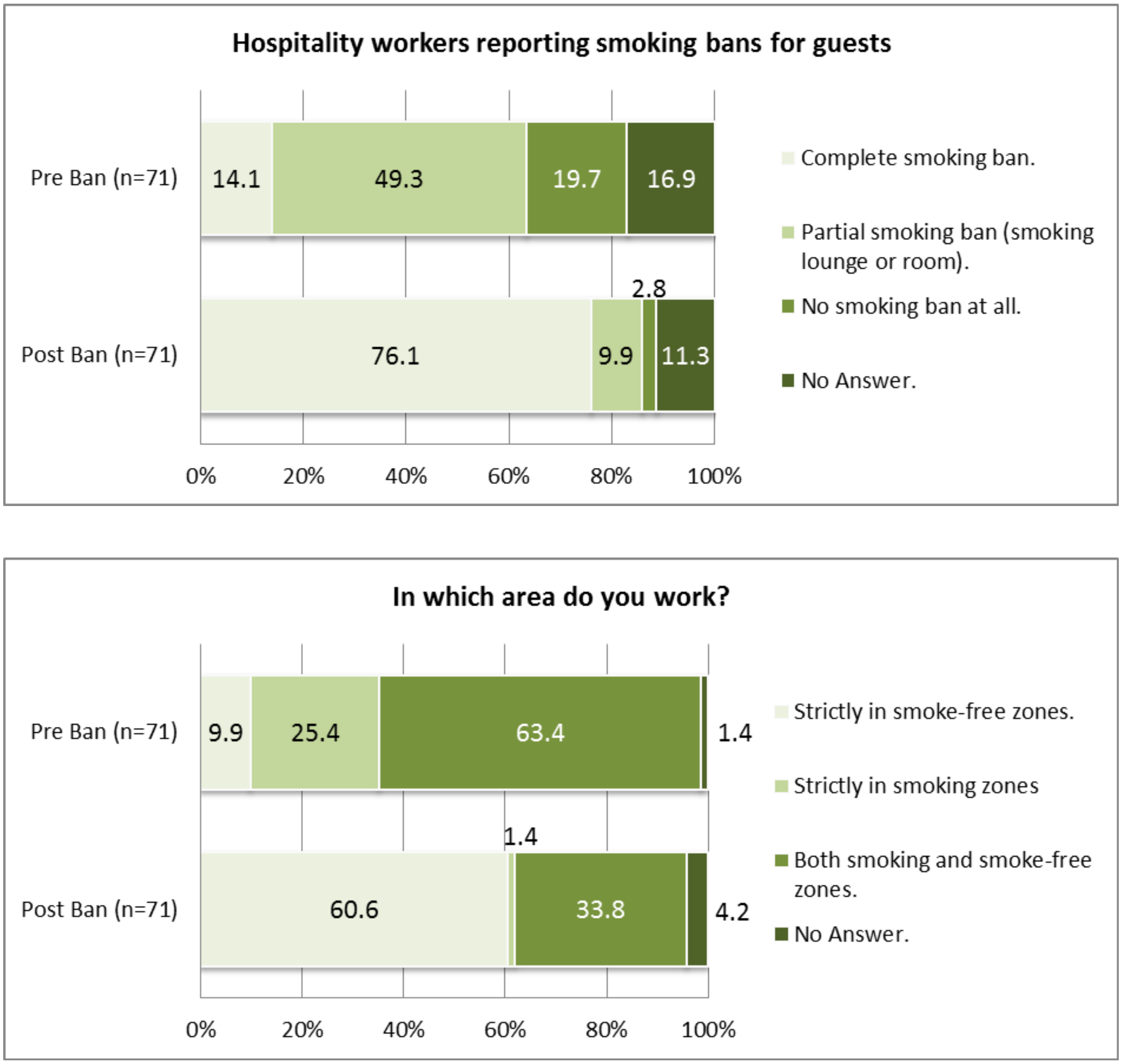


Figure 7-1 Implementation of smoking regulations in hospitality venues before and after the Swiss Tobacco Control Act (n = 71)

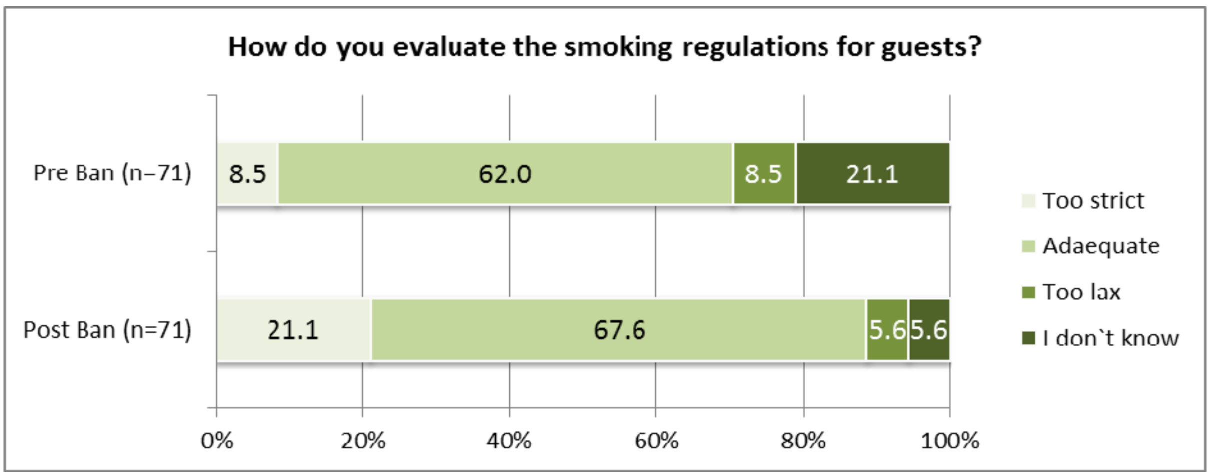
RESULTS

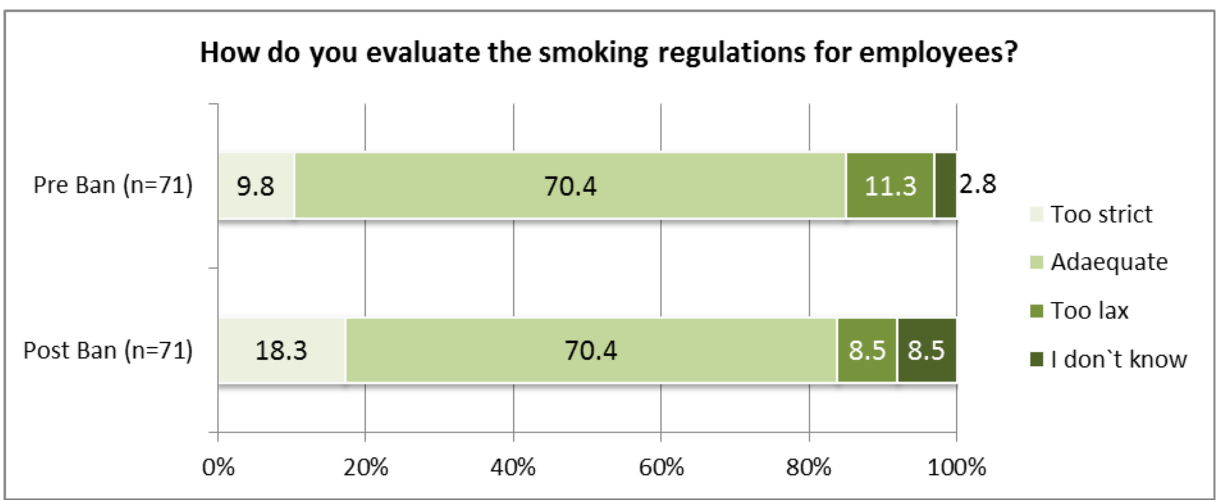
In the matched longitudinal sample (n=71) 49.3% were non-smokers (including ex-smokers) and 64.8% were women. The average age was 40.0 (95%-CI: 36.9 to 43.2).

For 85.5% working in the hospitality sector was the main employment and 85.5% were permanently employed.

Implementation of smoking regulations in hospitality venues

The smoking regulations for guests and employees before and after implementation of the law are shown in Figure 7-1. Compared to 14.1% before the law, 76.1% of the hospitality workers reported a complete smoking ban after implementation ($p<0.001$). More than half of the employees exclusively worked in strictly smoke-free areas (60.6%) after the ban came into effect, while only 1.4% reported still working in smoking sections only ($p<0.001$).





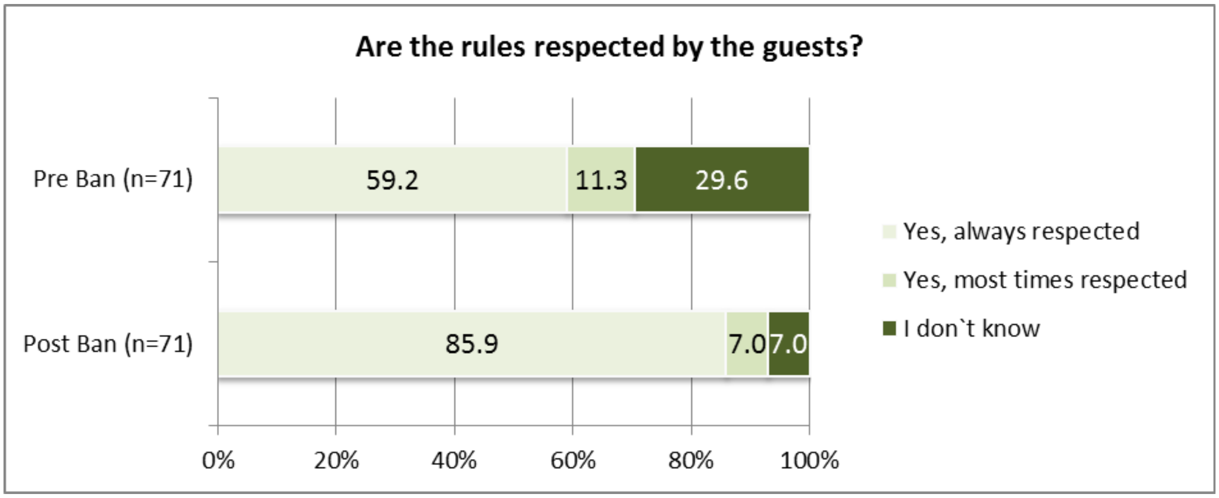


Figure 7-2 Compliance with smoking regulations in hospitality venues before and after the Swiss Tobacco Control Act.

Pre Ban all: All baseline respondents. Pre Ban med only: All baseline respondents that participated in the medical examination (not covered in this article). Pre Ban matched sample: All respondents that also participated twice, at baseline. Post Ban matched sample: All respondents that also participated twice, at follow-up

Changes in compliance and acceptance

Figure 7-2 shows changes in compliance with smoking regulations in the venues. The majority of hospitality workers considered the prevailing smoking regulations for both guests and employees to be adequate – both before and after the new law. After it came into force, more persons considered the current smoking ban as too strict both for guests (plus 12.6%; p=0.013) and employees (plus 8.5%; p=0.25). Nevertheless, regulations were more often reported to be respected by guests (p=0.001) and employees (p=0.16). From baseline to follow up, the percentage of study participants who felt annoyed by SHS at work dropped from 52.9% to 13.4% (p < 0.001). From baseline to follow up, the percentage of study participants who felt annoyed by second hand smoke as a guest dropped from 50.0% to 42.4% (p = 0.628). In addition, Figure 7-2 shows that there was no bias when comparing way of recruitment for the study (during medical exam or via mail) and when comparing base-line results for baseline only vs. longitudinal participants.

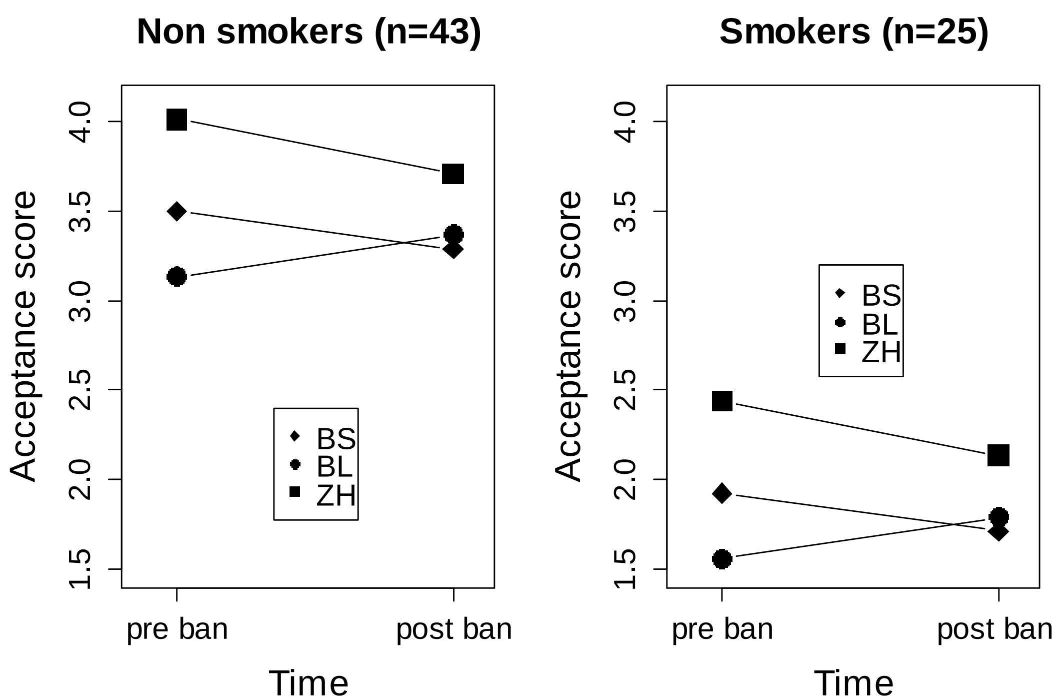


Figure 7-3 Changes in acceptance of smoking ban in Basel City (BS), Basel County (BL) and Zurich (ZH)

Figure 7-3 shows similar changes of the acceptance in relation to the stringency of the cantonal law for both smokers and non-smokers: In ZH and BS, two cantons that allowed exceptions, acceptance had decreased six months after the law. In BL where a complete smoking ban was implemented, acceptance increased for both non-smokers and smokers (p=0.09 for interaction between canton and pre/post acceptance).

Factors associated with acceptance

In our longitudinal sample, follow-up-acceptance correlates significantly with perceived annoyance at the workplace (r= .71) and as a guest in private (r= .74). Figure 7-3 shows that non-smokers had a higher acceptance score than smokers at all times (p<0.001). Among non-smokers the acceptance score changed from 3.55 (95%-CI: 3.24 to 3.87) at baseline to 3.43 (95%-CI: 3.12 to 3.73) at follow-up, in smokers the score dropped from 2.11 (95%-CI: 1.71 to 2.52) to 1.87 (95%-CI: 1.47 to 2.72). A multiple regression analysis showed that perceived annoyance as a guest in private and smoking status affects acceptance whereas age, sex, and perceived annoyance in the workplace were not significantly correlated with acceptance (Table 7-3).

DISCUSSION

Main findings of this study

This longitudinal study evaluated heterogeneous smoking regulations in hospitality venues in Switzerland implemented via a national Tobacco Control Act in May 2010. Our results show that smoking regulations were considerably tightened after the law came into effect, leading to a complete smoking ban in most of the hospitality venues investigated (82.5%). The implementation also improved self-reported SHS exposure, as more hospitality workers worked in less exposed areas after the law.

Hospitality workers reported better compliance of the guest and the employees with the smoking regulation after the regulations have been tightened, although the proportion of hospitality workers who evaluated the newly introduced smoking bans as too strict for the guests and themselves has increased. Regarding the factors influencing acceptance after implementation of the law, the current smoking status (non-smokers vs. smokers) and perceived annoyance with SHS as a guest in private proved to be significant, explaining a large part of the variance.

What is already known

A large population survey found a marked reduction of SHS exposure in Swiss restaurants at the end of 2010 (30) that was also confirmed with measurements in our study (31). Earlier international studies observed an increase of the overall level of acceptance after implementation of statutory smoking regulations, a finding we consistently only could confirm for the canton that introduced a strict smoking regulation (5, 32). Previous studies also showed that such smoking restrictions are accepted by both non-smokers and smokers (9, 11) although acceptance is highly influenced by personal relevance (23, 25) – as exemplified by our finding that feeling annoyed by second hand smoke in private as a guest predicts follow-up acceptance of smoking regulations. The finding that none of the other examined factors (sex, age, perceived annoyance with SHS in the workplace) were related to acceptance is in line with the results of general acceptance research.

What this study adds

This study provided the rare opportunity for a comparative, longitudinal study of the differential impact of different smoking regulations between cantons within the comparable cultural context of a single country. Our observation that tightened regulations are better complied with may indicate that stricter rules are more current and thus better followed. An alternative explanation may be social desirability - that employees did not want to risk any problems by admitting that rules are not respected at the time of the interview.

Contextual factors may explain the relatively small change of acceptance after the introduction of the ban compared to other countries (5, 32). Due to the political system of basic democracy in Switzerland, the pros and cons of the new law were heavily discussed in the media and in public long before the law came into effect. Such a public discourse can stabilize the formation of opinions and consequently individual acceptance of the law before its implementation (6).

We found a striking pattern with respect to the type of smoking regulation. In the canton that implemented a comprehensive ban, acceptance in both smokers and non-smokers was lowest prior to the introduction of the ban and increased afterwards, whereas in the two other cantons with incomplete smoking bans acceptance score decreased between baseline and follow-up.

Although not statistically significant in our small sample, this suggests that a complete ban without exceptions is the least contended. In contrast, implementation of an incomplete law does not have the same positive effect on increasing acceptance as a clear, unambiguous regulation. This provides additional support for the WHO recommendation of complete smoking bans.

Limitations of this study

Due to the intense and emotional public debate on the smoking ban, it was difficult to recruit hospitality workers for the study, leading to a small sample size and potentially to a selection bias towards workers who already had a higher acceptance of the law compared to non-participants. Further, our sample mainly consisted of German-speaking hospitality workers. This indicates that non-participants may not have completed our survey due to language problems and that one should not generalize the results to non-German-speaking hospitality workers. Thus, we assume there to be more smokers and lower acceptance among non-participants. At study-follow-up, we did not observe a selection bias as the respondents that participated twice did not significantly differ in acceptance at baseline from the sample that only responded once. Also, as the follow-up observations were carried out within four to six months after implementation of the law, long-term effects of the smoking ban cannot be assessed.

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Competing interests

None declared.

Table 7-1 Overall sample size and response rates stratified for the different cantons

	Total (n=185)		AG (n=5)		BL (n=18)		BS (n=101)		ZH (n=61)	
	All	Med only (n=57)	All	Med only (n=1)	All	Med only (n=14)	All	Med only (n=25)	All	Med only (n=17)
Response rate baseline (%)	109 (58.9%)	41 (71.9%)	0 (0%)	0 (0%)	15 (83.3%)	11 (78.6%)	61 (60.4%)	18 (72%)	33 (54.1%)	12 (70.6%)
Response rate follow-up (%)	83 (44.9%)	43 (75.4%)	0 (0%)	0 (0%)	14 (77.8%)	12 (85.7%)	43 (42.6%)	18 (72%)	26 (42.6%)	13 (76.5%)
Response rate matched sample (%)	71 (38.4%)	35 (61.4%)	0 (0%)	0 (0%)	13 (72.2%)	11 (78.6%)	36 (35.6%)	14 (56%)	22 (36.1%)	10 (58.9%)

Table 7-2 Items chosen for 7-item acceptance scale rated on a six-point Likert-scale.

1	It is important to protect staff and guests from second hand smoke.
2	Public smoking bans infringe personal freedom.
3	Non-smokers are harmed by second hand smoke.
4	Non-smokers are bothered by second hand smoke.
5	Most of our guests agree to smoking bans in bars and restaurants.
6	Most of my colleagues agree to smoking bans in bars and restaurants.
7	The head of our venue agrees to smoking bans in bars and restaurants.

Note. Original German items are translated into English. Item 2 was inversely coded. Each six-point item ranged from "I completely agree" to "I do not agree at all" plus a response option "I do not know".

Table 7-3 Linear regression analysis predicting follow-up acceptance of smoking regulations (N=63)

Variables	Coefficient (95%-CI)	p-Value
Constant	2.07 (0.72 to 3.43)	0.003
Age	-0.01 (-0.29 to 0.01)	0.385
Sex [female]	0.18 (-0.34 to 0.71)	0.491
Being a smoker	-0.83 (-1.45 to -0.21)	0.009
Feeling annoyed by second hand smoke in private (as a guest)	0.36 (0.19 to 0.54)	<0.001
Feeling annoyed by second hand smoke at work	0.08 (-0.13 to 0.29)	0.431

Note. Total R^2 = 0.51

References

1. Rose A, Fagan P, Lawrence D, Hart A, Jr., Shavers VL, Gibson JT. The role of worksite and home smoking bans in smoking cessation among U.S. employed adult female smokers. American Journal of Health Promotion. 2011;26(1):26-36.

2. Deutsches Krebsforschungszentrum. Nichtraucherschutz wirkt - eine Bestandesaufnahme der internationalen und der deutschen Erfahrungen. Heidelberg: 2010.

3. Bauer JE, Hyland A, Li Q, Steger C, Cummings M. A Longitudinal Assessment of the Impact of Smoke-Free Worksite Policies on Tobacco Use. American Journal of Public Health. 2005;95(6):1024-9.

4. Eriksen MP, Gottlieb NH. A review of the health impact of smoking control at the workplace. American Journal of Health Promotion. 1998;13(2):83-104.

5. Fong GT, Hyland A, Borland R, Hammond D, Hastings G, McNeill A, et al. Reductions in tobacco smoke pollution and increases in support for smoke-free public places following the implementation of comprehensive smoke-free workplace legislation in the Republic of Ireland: findings from the ITC Ireland/UK Survey. Tobacco Control. 2006;15(suppl_3):iii51-8.

6. Schulz PJ, Hartung U, Fiordelli M, Faustinelli C. Rauchverbot in öffentlichen Räumen - Monitoring im Tessin. Schlussbericht über die Befragungswellen 1-3 sowie die Inhaltsanalyse für die Zeit bis zum Referendum. Lugano: Università della Svizzera italiana, 2007.

7. Grewe A. Implementierung neuer Anreizsysteme. München: Mering; 2000.

8. Eco U. Die Bibliothek: Hanser; 1987.

9. Borland R, Yong HH, Siahpush M, Hyland A, Campbell S, Hastings G, et al. Support for and reported compliance with smoke-free restaurants and bars by smokers in four countries: findings from the International Tobacco Control (ITC) Four Country Survey. Tobacco Control. 2006;15 Suppl 3:iii34-41.

10. Thomson G, Wilson N. Persisting loopholes in New Zealand's smokefree law on tobacco marketing. The New Zealand medical journal. 2007;120(1256):U2597.

11. Brenner H, Born J, Novak P, Wanek V. Smoking Behavior and Attitude Toward Smoking Regulations and Passive Smoking in the Workplace. Preventive Medicine. 1997;26(1):138-43.

12. Passivrauchen in der Schweizer Bevölkerung 2009. Tabakmonitoring – Schweizerische Umfrage zum Tabakkonsum [Internet]. Psychologisches Institut der Universität Zürich 2010.

13. Deutsches Krebsforschungszentrum. Erhöhtes Gesundheitsrisiko für Beschäftigte in der Gastronomie durch Passivrauchen am Arbeitsplatz. Heidelberg: 2007.

14. Allwright S, Paul G, Greiner B, Mullally BJ, Pursell L, Kelly A, et al. Legislation for smoke-free workplaces and health of bar workers in Ireland: before and after study. Bmj. 2005;331(7525):1117.

15. Eagan TM, Hetland J, Aaro LE. Decline in respiratory symptoms in service workers five months after a public smoking ban. Tobacco Control. 2006;15(3):242-6.

16. Eisner MD, Smith AK, Blanc PD. Bartenders' respiratory health after establishment of smoke-free bars and taverns. JAMA : the journal of the American Medical Association. 1998;280(22):1909-14.

17. Farrelly MC, Pechacek TF, Chaloupka FJ. The Impact of Tobacco Control Program Expenditures on Aggregate Cigarette Sales: 1981-2000. Journal of Health Economics. 2003;22(5):843-59.

18. Goodman P, Agnew M, McCaffrey M, Paul G, Clancy L. Effects of the Irish smoking ban on respiratory health of bar workers and air quality in Dublin pubs. American journal of respiratory and critical care medicine. 2007;175(8):840-5.

19. Larsson M, Boethius G, Axelsson S, Montgomery SM. Exposure to environmental tobacco smoke and health effects among hospitality workers in Sweden--before and after the implementation of a smoke-free law. Scandinavian journal of work, environment & health. 2008;34(4):267-77.

20. Bauer GF, Brügger A, Deplazes S, Emch A, Friedrich V, Hoffmann S, et al. Konzeption und Evaluation von Tabakprävention als integrierte Strategie des Betrieblichen Gesundheitsmanagements - Ergebnisse eines Forschungs-Praxisprojekts zur Verbreitung von Massnahmen des Betrieblichen Gesundheitsmanagements im Kanton Zürich. Zürcher Beiträge zur Arbeits- und Organisationspsychologie. Heft 1/2011. Zürich: ZOA, 2011.

21. Schulze A, Lampert T. Bundesgesundheitssurvey: Soziale Unterschiede im Rauchverhalten und in der Passivrauchbelastung in Deutschland. Berlin: Robert Koch-Institut, 2006.

22. Rost J. Lehrbuch Testtheorie, Testkonstruktion. Bern: Huber; 1996.

23. Lucke D. Akzeptanz. Legitimität in der "Abstimmungsgesellschaft". Opladen: Leske + Budrich; 1995.

24. Schade J, Baum M. Reactance or acceptance? Reactions towards the introduction of road pricing. Transportation Research. 2007;Part A 41:41-8.

25. Schade J, Teubel U. Public acceptability of transport pricing. IATSS Research. 1997;21(2).

26. Dailey RM, Richards AA, Kluever Romo L. Communication with significant others about weight management: The role of confirmation in weight management attitudes and behaviors. Communication Research. 2010;37(5):644-73.

27. Passivrauchen in der Schweizer Bevölkerung 2006. Tabakmonitoring – Schweizerische Umfrage zum Tabakkonsum [Internet]. Psychologisches Institut der Universität Zürich 2007.

28. WHO. Guidelines for Controlling and Monitoring the Tabacco Epidemic. Geneva1998.

29. Sistek D, Tschopp JM, Schindler C, Brutsche M, Ackermann-Liebrich U, Perruchoud AP, et al. Clinical diagnosis of current asthma: predictive value of respiratory symptoms in the SAPALDIA study. Swiss Study on Air Pollution and Lung Diseases in Adults. The European Respiratory Journal. 2001;17(2):214-9.

30. Der Tabakkonsum der Schweizer Wohnbevölkerung in den Jahren 2001 bis 2010. Tabakmonitoring – Schweizerische Umfrage zum Tabakkonsum [Internet]. Psychologisches Institut der Universität Zürich 2011.

31. Rajkumar S, Huynh CK, Bauer GF, Hoffmann S, Roosli M. Impact of a smoking ban in hospitality venues on second hand smoke exposure: a comparison of exposure assessment methods. BMC public health. 2013;13:536.

32. Borland R, Owen N, Hill D, Chapman S. Changes in acceptance of workplace smoking bans following their implementation: a prospective study. Preventive Medicine. 1990;19(3):314-22.

> "It is apparent that the effects of SHS on others is now the most powerful antismoking weapon being employed against the industry."
>
> Philip Morris 1987

8 SUMMARY OF THE MAIN FINDINGS

The overall aim of this study was to examine changes in SHS exposure and cardio-respiratory health in non-smoking hospitality workers as well as behaviour and acceptance in smoking and non-smoking hospitality workers. We compared an intervention group that experienced a smoking ban at the workplace to a control group that did not undergo any changes in exposure.

Did SHS levels in a hospitality venue reflect the current regulation?

We performed 225 badge measurements in 193 hospitality venues during baseline visits. First follow-up visits were conducted 199 days later, on average, in 51 venues with 58 badges. At the second follow-up, 42 badges were placed in 36 venues. The results of our SHS exposure measurements clearly reflected the present smoking regulation in the venue. Completely smoke-free venues had the lowest numbers with 0.1 cigarette equivalents per day (CE/d) (95% CI: 0.01 to 0.2; n=11) before the smoking ban while places without any restriction yielded the highest average value with 6.1 CE/d (95% CI: 4.7 to 7.5; n=93). Venues with partial smoking bans had as expected higher results in the smoking section (4.4 CE/d (95% CI: 3.2 to 5.5; n=93)) and lower in the non-smoking section (0.9 CE/d (95% CI: 0.5 to 1.6; n=28)). As there was only one venue with a non-smoking section that was separated by a door, it was not possible to stratify for another increment. There were 11 restaurants or cafés that applied a special time regulation before the ban, prohibiting smoking during mealtimes. In these venues exposure was lower than in an average restaurants (2.0 CE/d (95% CI: 0.5 to 3.5)), but exposure levels were in general lower in restaurants. We found the highest levels in bars (10.0 CE/d (95% CI: 7.1 to 12.9; n=36)), followed by cafés (4.5 CE/d (95% CI: 3.1 to 6.0; n=31)) and restaurants (3.3 CE/d (95% CI: 2.5 to 4.0; n=126)).

How did SHS exposure change after implementation of a smoking ban?

The intervention group comprised 56 persons at baseline, 44 persons at follow-up 1 (79 %) and 42 at follow-up 2 (75 %). These were compared to the control groups: 6

persons working in smoking venues that did not change their rule (Control Group I), 14 hospitality workers who had always worked in smoke-free environments (Control Group II) and 16 persons who were regularly exposed to SHS privately or at work without being employed in the hospitality sector (Control Group III). Two members of Control Group I returned for a second examination (33%), while 10 (62.5%) and 5 (31.3%) participants in Control Group III underwent second and third examinations, respectively. For analysis, Control Groups I and III were merged into one “exposed Control Group”. (More detailed information on the different control groups can be found in Section 3 of this thesis.)

We used a time-weighted average of the workplace MoNIC badge as exposure measure in all analyses. The two follow-up measurements were merged into one post-ban measure. Average exposure in the intervention group at baseline was 2.6 (95% CI: 1.7 to 3.4) cigarette equivalents/day (CE/d) and 0.2 (95% CI: 0.1 to 0.2) CE/d at follow-up resulting in an exposure reduction of 2.4 CE/d. In the exposed control group exposure at baseline was 2.1 (95% CI: 1.0-3.2) CE/d and 1.6 (95% CI: 0.7-2.5) CE/d at follow-up.

Which cardio-respiratory health factors in non-smokers were affected by long-term SHS exposure?

We examined two cardiovascular outcomes: heart rate variability (HRV) and pulse wave velocity (PWV). Respiratory outcomes were fractional exhaled nitric oxide (FeNO), lung function and self-reported symptoms.

In order to answer this research question we did a cross-sectional analysis of all baseline data and compared it if possible to reference values from large scale studies and to corresponding personal exposure.

We found spirometric outcomes FVC and FEV_1 to be lower in both men and women that had been before the ban compared to the average Swiss population.

When directly relating outcomes to exposure at baseline we assumed this would correspond to long-term exposure. We found an association with FeNO. Per unit increase in CE/d average FeNO values in our whole population decreased by 4.20 (-7.69 to -0.57) ppb (p=0.024).

Cardiovascular parameters and lung function parameters did not show any association with exposure at baseline.
From the respiratory symptoms we found cough to have a significantly elevated OR of 1.28 (95%-CI: 1.07 to 1.53; p-value: 0.007). Other symptoms were not associated to exposure in our sample.

Was there a dose-response relationship between current SHS exposure and cardio-respiratory health markers?
For this longitudinal analysis comparing exposure to outcomes under consideration of a within-subject correlation we created a random intercept model and calculated covariate-adjusted exposure response associations.
Both cardiovascular markers showed a strong correlation with exposure in this model. All parameters behaved according to hypothesis. SDNN increased by 1.8% (95%-CI:-0.1 to 3.8; p=0.069) per unit decrease in CE/d. RMSSD increased by 2.3% (95%-CI: 0.2 to 4.4; p=0.031), HF by 5.7% (95%-CI: 0.9 to 10.2; p=0.020), LF by 0.6% (95%-CI:-4.1 to 5.1; p=0.802) and Total Power by 4.1% (95%-CI:0.0 to 8.0; p=0.051) while the LF/HF ratio as expected decreased by -5.7% (95%-CI:-9.1 to -2.4; p=0.001).
Pulse Wave Velocity decreased by -0.72% (95%-CI:-0.40 to -1.05; p<0.001) per unit decrease in CE/d, also corresponding to higher arterial stiffness with higher exposure. Systolic blood pressure decreased very slightly.
This model did not show any association when done with spirometry or FeNO.

Did cardio-respiratory health improve after SHS exposure cessation irrespective of exact exposure?
This model explored changes in health from before to after the ban comparing the intervention group and the control group that remained exposed irrespective of exposure. For each outcome a linear mixed effects model with a random subject intercept was fit including a (study group*pre/post ban)-interaction term and adjusting for appropriate co-variables.

All HRV parameters were fairly close together at baseline and significantly diverged at follow-up. The strongest effect could be observed in HF (p=0.007) and the HF/LF ratio (p=0.009).

At baseline PWV was lower in the control group than in the intervention group and remained on a steady level at follow-up while the intervention group improved but without reaching numbers as low as the control group (p=0.12). Systolic blood pressure diverged with the intervention group decreasing and the control group increasing (p=0.129) but values had been different at baseline already.

Contrary to our expectations we observed a decrease in FeNO in the intervention group from 10.8 ppb (95%-CI: 9.3 to 12.6) to 8.0 ppb (95%-CI: 7.0 to 9.2) after the smoking ban that was significantly different from the control group which showed an increasing tendency from 11.0 ppb (95%-CI: 8.6 to 14.0) to 12.6 ppb (95%-CI: 9.6 to 16.5) (p=0.006).

We did not observe any development in lung function or a decrease in respiratory symptoms one year after the ban.

Were different regulations accepted and were they complied with? Which factors did acceptance depend on?

For the behaviour and acceptance survey evaluation we analysed the matched sample that comprised 26 smoking and 45 non-smoking participants. Compared to 14.1% before the law, 76.1% of hospitality workers reported a complete smoking ban after implementation (p<0.001). From baseline to follow up, the percentage of study participants who felt annoyed by SHS at work dropped from 52.9% to 13.4% (p < 0.001).

We found that non-smokers were more in favour of the smoking ban right from the start and remained so. In ZH and BS, two cantons that allowed exceptions, acceptance had decreased six months after the law. In BL where a complete smoking ban was implemented, acceptance increased (p=0.09 for interaction between canton and pre/post acceptance).

In general, Swiss hospitality workers continued to feel that the ban was too strict. We did not find any changes in smoking status or intention to quit. A large part of the questions that we asked did not give any significant results or even tendencies.

9 OVERALL DISCUSSION AND CONCLUSION

> "Portray the debate as one between the anti-smoking lobby and the smoker, instead of 'pro-health and public citizens' versus the tobacco industry."
>
> Philip Morris
> USA, 1992

The thesis abides by the strategic nexus of the Swiss TPH by contributing to innovation, validation and application of tools and research (Table 9-1)

Table 9-1 Contributions of this thesis to the strategic nexus of Swiss TPH

INNOVATION	VALIDATION	APPLICATION
The long-term effects of SHS exposure on heart rate variability and pulse wave velocity were assessed.		
The effects of SHS exposure cessation on HRV, PWV and FeNO were explored.		
	Several exposure measurement techniques were compared and evaluated.	
	A smoking ban was shown to be an effective intervention to protect cardiovascular health in non-smoking hospitality workers.	
		Published results were taken up in a political campaign exemplifying an attempt to translate research results into policy.

9.1 Our findings in context: How do they fit in with other studies?

Most prior smoking ban studies limited their health examinations to respiratory symptoms and lung function measurements (90-94). This study was the first to look at cardiovascular markers in relation to long term SHS exposure cessation.

In this section the main findings mentioned in the previous sections are discussed cross-sectionally.

Did SHS levels in a hospitality venue reflect the current regulation?

We were able to reproduce results from previous studies with our SHS exposure measurements that reflected the present smoking regulation in the venue (20). The high levels of SHS we found in bars underline the common ground of drinking and smoking that has been documented in other studies (95). A German study also included clubs and discotheques and found PM levels there to exceed bars considerably (96), but we did not include any such venues.

What is the most suitable way of assessing personal SHS exposure?

The three exposure measurement methods we applied gave us five parameters to evaluate and compare.

The most conventional way to assess exposure is by questionnaire. In large monitoring studies this method can give a good overall impression of regular exposure patterns (97). For direct comparison with health outcomes, however, it may not be sensitive enough. Self-reported data is subject to recall bias and categorical answers that cover wide ranges such as number of years and hours per day that people were exposed make them fairly inaccurate. In comparison to active smoking, remembering details of passive smoking can be even more difficult, especially in times when indoor smoking was still commonplace. To address this issue we included some specific questions in our study to complement the badge and saliva results. We found no correlation.

Using biological samples such as blood, saliva or urine to detect nicotine and cotinine is one method to measure SHS exposure which has been applied in studies measuring only exposure (98) or exposure in relation to health factors (92, 99). Usually cotinine is used as it has a longer half-life than nicotine and can therefore be detected for longer periods after exposure. Cotinine has been widely used as an objective and tobacco-specific exposure measure which has a high specificity and sensitivity (100). It may also be extracted from a hair sample allowing determination of long term SHS exposure from up to several months prior (101). This method has not been used very often, possibly due to lack of willingness from participants or interference by personal metabolism. In general, salivary cotinine can be recommended for the measurement of SHS exposure if sampling time is standardized and a detailed study protocol records the hours of and since exposure.

The MoNIC badge is easy to handle and delivers objective, nicotine-specific data. The badge was adapted from a method developed by Hammond and Ogden more than 20 years ago (102, 103). Two SHS exposure studies in South America applied the method reporting clear results (104, 105). However, the badge did not establish itself as a standard method. SHS studies preferably measured a proxy such as $PM_{2.5}$ (106-108), derived nicotine from VOC (volatile organic compounds) measurements (96), used a questionnaire (109) or sampled biomarkers for personal exposure (110). Variable methods make a direct comparison of studies more challenging.

As we were primarily interested in changes in workplace exposure we chose the workplace badge as a basis to calculate a time-weighted average for each person to control for workload and decreasing levels when the venue is closed (see Article 1, Section 4). The personal badge was too day-specific and included time periods at home or at leisure that were not of interest to us and distorted results. The clear results of the baseline venue measurements underline the usefulness of the MoNIC badge as a passive sampler for on-site measurements. In future studies it could also be suitable for outdoor measurements at building entrances or bus stops. To measure personal SHS exposure by wearing a badge, specific localities and activities during measurement need to be taken into account. A combination with a timely biological marker may be recommended.

When correlating the workplace and the personal badge the coefficient of determination was fair (R^2=51%; $p<0.001$), but with salivary data it was poor (R^2=0.9% for personal badge vs. cotinine) as in the validation study (R^2=4.5%) (88). Practical issues regarding the three methods are discussed in section 9.2.

How did SHS exposure change after implementation of a smoking ban?

We oversampled restaurants compared to bars, especially at follow-up as there were hardly any participants that worked in bars. This presumably led to underestimation of the true decrease in SHS levels in hospitality venues.

Exposure in the intervention group decreased significantly compared to the exposed control group. Surprisingly, even this group experienced a slight decrease in exposure. This trend is probably biased due to loss to follow-up. It may even be the case that guests in smoking venues reduced their tobacco consumption as a result of the surrounding debate.

Opponents of the ban had predicted that smoking would be relocated to other places once a smoking ban was in force, in particular to homes and thereby children would be more prominently exposed (111). Studies refuted these claims (112), showing that a comprehensive smoking ban actually led smokers to be more considerate even in private homes and to also feel more disturbed by SHS (113).

Which cardio-respiratory health factors in non-smokers were affected by long-term SHS exposure?

We found lower spirometric outcomes in exposed persons compared to the average Swiss population before the ban. This finding was in line with other studies (90, 93, 114). Several large-scale studies had defined reference values based on sex, age and height (115-117). Not all outcomes that we examined in this study offer such reliable reference values. Different studies on FeNO offer reference values, which cover a very wide range and did not prove useful in the cross-sectional comparison (118-120). To produce HRV reference values large scale studies are still needed as methods to date have been diverse (121). The only study offering reference values on pulse wave velocity (PWV) used categories with wide ranges (122). This parameter is not yet sufficiently explored and a more extensive assessment to produce reference values is underway (A. Schmidt-Trucksäss, personal communication).

In addition to comparing baseline values to reference values of the average population, we examined if outcomes were directly related to exposure assessed by the MoNIC badge at baseline. We assumed this measurement would correspond to long-term exposure and found an association with FeNO, in alignment with a previous study (123). As FeNO is known to be more erratic in asthmatics we

stratified for asthma. The effect remained significant in non-asthmatics but due to small sample size we could not consider asthmatics separately.
Examining effects as continuous variables in linear regressions is an advantage. As in comparable studies we looked at respiratory symptoms as binary variables but logistic regression is less meaningful. Our lack of significant results in respiratory symptoms is probably also due to sample size as there were some tendencies, according to hypothesis, that were not statistically significant.

Was there a dose-response relationship between current SHS exposure and cardio-respiratory health markers?

In this longitudinal model we compared exposure to outcomes under consideration of a within-subject correlation. Several HRV parameters as well as PWV were linked to exposure. This model did not show any association when using spirometry or FeNO as outcome. Previous studies assessing $PM_{2.5}$ as an exposure proxy for SHS evaluated exposure and outcome separately without directly relating them to each other as we did in this model (93, 124). A further study examining serum cotinine asked participants about the number of hours they were exposed but also did not try to associate these numbers directly with health parameters (125).
This analysis is fairly unique to this study and the significant associations in cardiovascular measure are an important finding. It also emphasizes the workplace badge as an appropriate exposure approximation and highlights the sensitivity of both HRV and PWV in relation to SHS exposure.

Did cardio-respiratory health improve after SHS exposure cessation irrespective of exact exposure?

This model explored pre/post changes in health comparing the intervention group and the exposed control group without considering exact levels of exposure. Our time-weighted exposure proxy, though being objective, still comprised some assumptions. It therefore made sense to look at health outcomes separately. Furthermore this model is that which is most commonly used in other studies and results were therefore easier to compare.

HRV parameters were fairly close together in both groups at baseline and significantly diverged at follow-up. What was remarkable is that HRV parameters actually decreased in the control group adding to the effect of oppositional development between groups. PWV remained at a steady level in the control group but was lower at baseline. The intervention group did not reach such low numbers even at follow-up when PWV had improved. To the best of our knowledge this was the first study to examine HRV and PWV before and after a smoking ban. Previous studies looked at short term effects of SHS on HRV in humans (126) or mice (127) and found diminishing HRV parameters upon SHS exposure. Another study found effects using ordinal categories derived from a questionnaire as a chronic exposure measure and a 24hrs Holter ECG (128). The length of a recording needs to be standardized within a study, but the direction of an effect may still be compared between studies using different ECG procedures (129). It is important to note which parameters showed an effect, if they were time-domain or frequency–domain measures. Also when using NO_2 or ozone as exposure parameters cardiovascular effects were observed but these studies applied models that were difficult to compare to ours (128, 130).

FeNO decreased in the intervention group at follow-up contrary to our expectations that were based on previous studies (131, 132). This evolvement was significantly different from the exposed control group that experienced an increase. However, according to our medical advisors this effect, though statistically significant, is not clinically relevant. Clinical relevance is usually predefined and needs to be distinguished from statistical significance. In contrast, results of high clinical relevance are not automatically unimportant if there is no statistical significance (133). In our case it was unfortunately the other way around as FeNO seems to be very variable and highly influenced by a number of personal factors that were difficult to control for. Previous studies also delivered contradictory and confusing results. In some studies sex had an influence (119, 123), whereas in other articles it was atopy which was influential on FeNO levels (134).

Previous studies documented improvements in FVC but not in FEV_1 or $FEF_{25\text{-}75\%}$ after a smoking ban (91, 93). We did not observe a clear direction in lung function development one year after the ban even though it was below average in exposed subjects at baseline. This can be caused by several factors: the study sample was too small, lung function takes longer to recover or lung function does not recover at all. Lung function measurements can also be influenced by many factors such as current fitness and personal exertion that in turn may depend on the commitment of the study nurse. In our analysis the study nurse was only marginally associated with the outcome suggesting a balanced behaviour.

The fact that we did not find any decrease in respiratory symptoms is fairly surprising given that previous studies found very consistent results (91, 92, 124, 125). We based our questions on the SAPALDIA[3] questionnaire instead of asking the typical questions usually evaluated in smoking ban studies. These always enquire after teary eyes and irritated nose symptoms. Comparability is therefore limited and our questions might have been less relevant in this context.

Were different regulations accepted and were they complied with? Which factors did acceptance depend on?

In evaluating the behaviour and acceptance survey we analysed the matched sample comprising 71 participants. In this analysis the limited sample size was even more perceptible. We found that non-smokers were more in favour of the smoking ban from the start and remained so. Strikingly though, acceptance grew in both groups in the canton of BL, the canton which implemented the most comprehensive law. The law in both ZH and BS was full of loopholes and did not experience high levels of acceptance. This observation is in line with studies from other countries (135, 136). In general, Swiss hospitality workers continued to feel that the ban was too strict.

Perceived annoyance in private and smoking status affected acceptance whereas age, sex, health status and perceived annoyance in the workplace were not significantly correlated with acceptance. This is not in line with a previous study (137) and may well be a coincidental finding. We did not find any changes in smoking status or intention to quit in the 26 smoking participants. A previous study

[3] SAPALDIA (Swiss study on Air Pollution and Lung Disease in adults) is a cohort study in the Swiss population, which studies the effects of air pollution on the respiratory and cardiovascular health in adults.

had reported clear increases in smokers intention to quit after implementation of a comprehensive ban (138).

A large number of the questions that we asked did not give any significant results or even tendencies. Some questions turned out to deliver a very trivial message and could have been used as covariates or to support a more striking conclusion, which we did not find.

9.2 Methodological issues: What are the strengths and limitations?

Study Design

The special situation in Switzerland with heterogeneous smoking ordinances in a small geographical area served as an unusual quasi-experimental setting to investigate health effects of low SHS exposures. Bias from time trends is unlikely in this study because a control group that was not affected by the implementation of a new smoking ordinance was included. Many prior smoking ban studies were not able to include a control group (139, 140). In the cantons we worked in, very few venues remained smoking areas and were therefore eligible for the control group. Thus, we were forced to include more remote regions. This in turn made it more difficult to convince participants to travel to the study centre.

The prospective cohort study design minimized recall bias. It may be more costly and time-consuming but within-subject comparisons have a considerably higher statistical power and are less vulnerable to confounding because each person serves as its own control. Exposure and health outcomes were measured at the same time. Two follow-ups promised to allow more accurate tracking of health changes, though we could not fully benefit from this due to small sample sizes and merged follow-up data. As the original control group that continued to be exposed to SHS was too small, we had to include two additional groups making the entire control group very heterogeneous.

Recruitment

Recruitment was the biggest challenge in this study. It was extremely time and resource consuming. We had to extend it for several months and include further control groups with different eligibility criteria.

By the time ethical clearance came through at the end of 2009 there remained only 4-5 months to recruit participants and perform baseline examinations. Decisions on when laws are implemented can be on short notice and May 2010 was unexpectedly early in this case. It had been clear that BS would already change law in April but BL had planned to implement the more stringent cantonal law only at the end of the year 2010. This was preponed in order to avoid confusion by first changing to the national law in May and then further tightening to the cantonal regulation seven months later. These sudden changes posed unexpected time constraints on our study team. We hired a second study nurse to support recruitment and perform baseline examinations at the second study centre. Additional adjustments were taken, but nevertheless, the preconceived sample size could not be reached. Further reasons are discussed in section 9.3.

We were obliged to continue recruiting the control group after the ban. As these participants were not to experience any changes in exposure, we did not consider this to lead to any bias. But recruitment did not go more smoothly as there were only few smoking venues left and non-smoking employees turned out to be a rarity in these venues. Unfortunately we could not profit from the "Fümoar Club" (for details see introduction) in Basel which experienced a large influx of members. Hospitality owners were not inclined to participate in our study. We also observed some peer pressure in some venues which led to complete teams declining our invitation.

To enlarge the control group we tried to locate persons not working in the hospitality sector but exposed to SHS on a regular basis either at work or in private by means of an online advertisement. Out of 71 interested persons, 16 (22.5%) could eventually be included in the study. The majority did not respond again and some were occasional smokers and therefore not eligible. For a more comprehensive cross-sectional baseline survey we then recruited hospitality workers who had always worked in smoke-free venues such as canteens. There was a larger proportion of non-smokers in these venues and 14 persons underwent the examination.

Exposure Measurements

We collected exposure data using three different methods.

Questionnaires were conducted in two parts: an oral interview and distributed on paper to be returned by post to shorten the examination time. 79% were returned at baseline, so we asked participants at follow-up to immediately fill in the questionnaires and got complete data sets.

Saliva was sampled during the medical examination. Compared to blood samples saliva can be obtained non-invasively. Urine samples could have been another choice, especially as some participants expressed serious problems in producing enough saliva (1ml). Technical issues at the lab resulted in further missing values and a large number of samples were below the detection limit (0.1ng/ml). When sampling bodily fluids to determine nicotine and cotinine the exact time point of collection in relation to the time of exposure is crucial. The original plan in our study was to schedule medical examinations immediately after a work shift but this turned out to be impracticable. Most participants only agreed to come on their day off as they were too tired or too busy on their working days. Consequently the saliva samples were not comparable.

In a future study participants may have to be asked to independently take their saliva sample immediately after a work shift to deliver more consistent and comparable results.

Two MoNIC badges were evaluated per person, one from the workplace which measured ambient nicotine over the course of a week and a second badge that participants wore on themselves for 24 hours.

The badge that was placed at the venue was the easiest and most reliable method because we could easily control and document surrounding circumstances ourselves. Only in two instances the badge was thrown away during the course of the week. The personal badge turned out to be more challenging because participants did not always document clearly where they wore the badge and for how long. The badge protocol also turned out to be too superficial to accurately trace the number of hours the badge was worn at which place. Some badges were handed in after the medical examination because participants had forgotten them. It was also crucial to store the badge in the plastic case and in most cases participants complied with this instruction. For the exposed non-hospitality group we did not have any workplace badge and were obliged to use the personal badge as exposure measure.

The decrease in exposure according to hypothesis as measured by the badge could not be observed when evaluating the salivary sample and questionnaire data, underlining the limited reliability of these two methods in our study setting.

Health Examinations

Examining many objective health outcomes made this study an unusually comprehensive research project in the field of low dose SHS exposure and health effects of smoking bans. However, this also made the medical examination fairly long and laborious.

Hip and waist circumference as well as height, weight and blood pressure were straight forward measurements and served as important covariates in analyses.

The skin prick test gave an objective insight on allergy prevalence. With the help of a specialist from the allergy station at the university hospital we selected six of the most common allergens in order to cover the broadest range possible. In addition we included a positive and a negative control. Allergy prevalence was strikingly high in our sample compared to the average Swiss population (68% vs. 23%) (141).

The electrocardiograms in our study were of very high quality according to our collaborators who analysed the recordings. Some were slightly short and did not permit utilization of two non-overlapping sequences as had been planned, so a single sequence was used in these cases.

During the ECG participants lay flat on their back for ten minutes which served as preparation time for the PWV measurements. From a logistic point of view it would have been an advantage to have a mobile study centre as the medical examination was very extensive and required a fair amount of personal interest and commitment from the study participants. Arterial stiffness would not have been possible to include in such a setting as the measuring device was very bulky, cumbersome to transport and fairly sensitive to being moved.

Lung function measurements were performed with a small portable device using a nose clip. Results could instantly be read and transferred to a specific software producing a descriptive results page to print out for participants. If quality was insufficient up to eight spirometries had to be performed, a task which can be exhausting and requires some personal commitment on behalf of the study participant. Even though our quality standards were slightly lower than for example in the SAPALDIA study, we had to exclude a number of measurements because sufficient quality was not achieved until the end. This may have caused bias.

FeNO measurements were considered challenging by some of the participants as in this test wearing a nose clip is not permitted but breath should not go through the nose. Air was exhaled into a bag that needed to be analysed at the hospital within 12 hours. This was complied with at all times.

Data Analysis

Three statistical models were created to analyse the data. The cross-sectional model at baseline allowed comparisons to reference values and long term SHS exposure. In the longitudinal analysis we further checked for association of exposure and outcome in a mixed model clustering by individuals. In the third model we looked at pre/post changes without taking exposure into account to rule out exposure misclassifications.

Sample size was found to be the major limiting factor when analysing the data. When assessed as two follow-ups the results were erratic. We therefore decided to combine both follow-up measurements into one post-ban measure to increase study power. Unfortunately, the aim of monitoring developments of health outcomes in more detail after 6 and after 12 months was forfeited with this necessary step.

Stratification was restricted as groups were too small. This made it impossible to conduct some potentially interesting analyses.

9.3 Hospitality workers: Is this a suitable study population?

The sample of the medical study comprised 92 non-smoking participants at baseline, 56 at first follow-up (60.9%) and 48 at second follow-up (52.2%). The matched sample of the acceptance questionnaire counted 71 persons. Sample size remained below expectations in both parts of our study despite several amendments to the recruitment procedure.

Sample size

Most smoking ban studies with hospitality workers included both smokers and non-smokers. An Irish publication from 2005 examined 329 bar workers out of which 158 were non-smokers (99). 76% came back at follow-up. Participants had the option of being interviewed at the workplace if they did not wish to come to the laboratory. From a 371 Scottish sample, 51% participated a second time. In this study, sampling and spirometry were performed at the workplace itself (124). Other high impact studies also worked with smaller samples of 67 or 105 participants (91, 125). An American study examined urinary cotinine in 24 non-smokers working in bars or restaurants, and finding significant results did not mention any recruitment problems (110). A landmark study reporting on acute SHS exposure and HRV used a sample of 16 adults but with large effects, this can be enough (126). A Swiss study comparable to COSIBAR, recruited 105 smokers and non-smokers before the ban and performed exposure and lung function measurements at the workplace. 66 (62.9%) persons agreed to take part a second time (90). They reported similar problems to ours in recruiting. We can conclude that our recruitment success was not exceptionally low considering that participants had to sacrifice several hours per examination. Our loss-to-follow-up rate was fair under the circumstances.

Hospitality workers

In the USA, hospitality workers are an occupational group with one of the highest smoking prevalences (57, 142). A European study examining smoking prevalences in different occupations did not stratify for waiters (143, 144). But the numbers are probably similar. A large part of our target group was not eligible for the medical part of our study as they were smokers. Non-smokers who continued to work in a smoking environment, and could have been included in our exposed control group, were even rarer. However, the behaviour and acceptance survey that included smokers faced similar recruitment problems. Being a smoker is generally associated with a poorer response rate in studies (145).

When we approached venue owners we experienced a very open hostility towards the smoking ban which was reflected in an extreme unwillingness to participate in a scientific study connected to the ban. We seemed to blur into a group with the political powers that had decided to enforce this rule. Discussions were often emotional reflecting the venue owners' fear of losing business due to the new ban. Timing was therefore a major disadvantage in our recruitment process. When things had calmed down after the ban and we tried to find more members for our control group, it did not get easier as there were less eligible venues.

Hospitality workers are a vulnerable population group because they are (partly) excluded from the law on SHS protection at the workplace in many countries (76). Arguments often voiced in the Swiss debate that workers themselves have the right to choose if they want to work in a smoking environment seem absurd. The job market is competitive and a person refusing to work in the smoke would probably not get hired to work in a venue with a smoking section.

We did not offer any incentive for people to participate apart from a free medical examination and a cinema voucher. The fact that employees of the hospitality sector work in shifts made it difficult to schedule appointments and impossible to have everyone come straight after work for a more standardized procedure as originally planned.

The medical examination in our study was fairly extensive taking almost three hours at baseline. In addition participants were asked to fill out a further questionnaire at home and wear the MoNIC badge for 24 hours. This effort might have been too time-consuming for some.

Before smoking was banned in aircrafts flight attendants were highly exposed at their workplace and subject to numerous studies on SHS exposure and health effects (146-148). Flight attendants can be considered a subgroup of hospitality workers. Negative health effects on personnel caused by passive smoking were a major concern of the labour union that played a vital part in banning smoking in aircrafts (149). Tobacco industry strategies against the establishment of smoke-free worksites failed in the case of airlines, probably because their strongest argument of economic losses was shown to be obsolete.

We concluded from our experience that health issues were not a prominent topic in this occupational group. Possibly there was a selection bias in our sample that may have consisted of persons more interested in health topics and therefore more aware of a healthy lifestyle in general. Participants entering a study tend to be different from those that refuse (150). At screening no one had to be excluded for previous health incidents such as for example a heart attack. A person working in the hospitality sector needs to be in adequate health for this physically demanding job suggesting a healthy worker effect (151).

The unwillingness to take part in scientific studies can also be observed in other population groups in Switzerland, for example in school children who are regularly asked to participate in research projects (B. Bringolf, personal communication). There seems to be a feeling of saturation of requests to participate in a research project which does not offer a clear personal benefit. In developing countries researchers are often met with more enthusiasm but issues surrounding informed consent can be more challenging.

Future studies need to simplify procedures as much as possible for participants, either by performing examinations at the workplace, limiting their length or reducing the number of follow-ups and avoiding repetitive, long questionnaires. A monetary incentive may be effective but does not comply with ethical standards in some countries (152-154). Furthermore it is important to increase public awareness with research (155).

9.4 From research to policy: How could our results impact policy-making?

In the course of this study we faced the extraordinary opportunity of immediately applying our study results in an on-going political debate. After implementation of the national smoking ban in May 2010, which served as an external intervention for the study, there were two more popular votes on further changes to the smoking ban on a cantonal and a national level.

The first vote took place in BS in November 2011. It was an initiative by the Basel hospitality association, mainly promoted by the aforementioned "Fümoar Club", to loosen the cantonal law to the level of the national law. Prior to this vote we presented our first preliminary results on SHS exposure changes and effects on HRV at the National Tobacco Conference in Berne. Our message was taken up with interest and a press release after the meeting included a recommendation from Swiss health prevention experts invoking our results to reject the BS initiative. The initiative was indeed rejected despite a delusive campaign by the hospitality association. The innkeepers emphasized that the "Fümoar Club" and the nuisance associated with membership cards could be abolished if the initiative would be accepted, completely disregarding that the disadvantages caused by the club were actually self-imposed and the club itself legally questionable. Given the way the campaign was led, it seemed possible that people would actually be deceived into voting for something they did not agree with. Eventually 50.23% rejected the initiative corresponding to a difference of only 212 votes in such a small canton. The result seems coincidental and in fact underlines the division among the population regarding a complete smoking ban in hospitality venues.

The second vote in September 2012 was a national initiative by the Swiss lung association attempting to unify the regulation for a country-wide comprehensive smoking ban on the level of the most stringent cantonal regulations, only allowing unserved smoking rooms. This campaign by the lung association was very much focused on health protection of all people at their workplace. Opponents of the initiative covered the whole political spectrum. They argued that the current law was still very new and venues had invested into constructing adequate smoking rooms and ventilation systems that most hospitality workers were smokers themselves and therefore did not need any protection from SHS, and that Switzerland was turning into a nanny state full of regulations that undermine the personal freedom of decision of its citizens. We issued a press release on the final cardiovascular results (improvement of both HRV and PWV) at the beginning of August 2012 in the frame of the Swiss Public Health conference where the study was to be presented. Due to the timeliness of the topic the response was substantial and many newspapers took up the subject. One to two months before the vote public-opinion polls showed more than 60% to be in favour of the lung association but during the last few weeks this number dramatically dropped leaving the initiative to be clearly rejected in the end by 66%. Only one canton (GE) accepted the initiative.

This was a dramatic blow for public health advocates in Switzerland and raised the question whether the campaign was badly run or if it had been built on the wrong arguments. How could support drop so dramatically in such short time? Despite being the most precious good of every human being, why does it not seem attractive to agitate for health in a political discussion as opposed to personal freedom?

The lung association seemed too health-focused and were accused of coercion. The new law stated that all workplaces should be smoke-free and adversaries pointed out that persons in single offices would also be affected causing a popular outrage. Presumably it would have been more effective to emphasize the unification and simplification of the law and the disproof of economic losses as had been shown in several international studies (156-159) as well as in Switzerland itself (160).

The system of direct democracy gives people a unique power to interfere with political decisions. Personal freedom of choice seems to have a high priority for the Swiss. Nevertheless this smoking ban debate seems to be a prime example of manipulation of the people by a non-transparent political system infiltrated by a powerful private lobby.

The federal government and parliament usually recommend rejecting initiatives as was the case with this initiative. Examples from other countries have shown how important a supportive government is when it comes to implementation of a smoking ban. In Turkey, a country with a high smoking prevalence and a long Shisha tradition, the prime minister and the health minister collaborated on this topic and established a ban in short time albeit in a different political procedure (161).

Financial arguments are among the most important. Ironically a smoking ban has been shown to be one of the most effective ways of decreasing health costs, an interesting fact for the country with the third-highest health expenditure of all OECD countries(162). Health costs incurred by active and passive smoking were widely ignored in the debate. Although it has been proven that this is not the case, there are still voices arguing that smoking bans destroy small traditional venues, especially in rural areas. More probably these traditional village restaurants are obsolescent hospitality models.

The tobacco industry has been very successful in controlling tobacco policy in Switzerland (27). It maintains strong alliances to both advertising agencies and print media. It openly attacked results of the SAPALDIA study that linked passive smoking to respiratory symptoms in 1995 (163). Through scientist R. Rylander from Geneva, who on behalf of the tobacco industry invented random “confounder variables” such as green vegetables to disguise the linkage between passive smoking and childhood bronchitis, the industry successfully played for time in implementing a smoking ban (164, 165). It has been shown that the industry made financial contributions to hospitality associations worldwide (72). It can easily be imagined that this is the case in Switzerland considering the vehement opposition of the hospitality sector to any smoking ban. In addition the marketing law in Switzerland is among the loosest in Europe even though constraining advertising is most effective with youth and only causes minor economic losses (166, 167).

The tobacco industry is now increasingly targeting developing countries where knowledge on negative health effects is not yet widespread and infectious diseases are more pressing. But more and more industrialized countries are adapting stringent laws. Probably even in Switzerland a complete national ban is only a matter of time. The women's right to vote also took longer than in any other industrialized country to be adopted here.

In some areas the debate is moving beyond banning smoking in workplaces to policies including full disclosure on smoking status. While the WHO has been hiring only non-smokers since 2008 (168), selected employers in the US such as the University of Pennsylvania have started to state in job ads that smokers will not be considered (169). They justify this by economic reasons but this also seems to open the field for a whole new discussion on discrimination and privacy.

Obviously the indoor smoking ban has led to increased smoking in outdoor areas of hospitality venues. Some countries have now started to ban smoking in selected outdoor areas and private places as well (76). The initiative from Geneva that is currently collecting signatures (for details see introduction) also steers in this direction (80). Time will tell if it will be taken up seriously in Switzerland at this stage. There have been too many discussions during the past few years, leaving people tired and saturated on this topic. It will, no doubt, eventually come up again.

9.5 Future tobacco research: What are key issues and goals?

Why still do tobacco-related health research?

Cigarette smoking is probably the most researched area in epidemiology (170). Research on health effects of active smoking delivered first results in the 1940s, the discussion on passive smoking emerged around 1980 and the first smoking bans were implemented around the turn of the millennium as a result of serious long-term campaigning by the anti-tobacco movement and unreserved support from the WHO. So why do we still design new studies to examine health effects related to tobacco consumption when it has been repeatedly proven that smoking substantially raises the risk for a range of serious illnesses and delimits life expectation?

Interesting health markers to explore tobacco-induced illnesses help us to better understand the exact pathways and complex interactions that lead to diseases. This can also support effective treatment and prevention. Health and control interventions always need to be evaluated in parallel to increase effectiveness (171).

Study results should be reproduced as statistical analyses are always subject to errors and every study has some limitations. With a powerful tobacco industry constantly trying to undermine and question study results it is that much more important to produce undisputable statements.

Surprisingly, even today among parts of the population the harmful effects of tobacco consumption are largely underestimated. While people agree that smoking is unhealthy, knowledge on the true risk and wide scope of illnesses that are promoted by active and passive smoking remains vague. Furthermore public awareness of the strong influence the tobacco industry has in political debates, through marketing schemes and by publishing their own research that downplays scientific findings, remains low (172).

For these reasons it is important to keep the topic in discussion and continue to educate the population on tobacco-related health impairments. In a controversial topic such as a smoking ban, cultural, political or even climatic differences are willingly deployed as arguments to fight against following other countries in terms of smoking regulations. Therefore, studies from other areas cannot often be used as evidence, and instead it is important to replicate study results from other countries locally. In the course of this project we observed how new findings from a national study were seriously taken up in the discussion, even though the overall message was the same as from other studies: exposure to SHS is harmful. But it proved necessary to show that this is also the case in Switzerland.

There are still a lot of prevalence studies being conducted examining different minorities and socioeconomic influences, and studies on co-morbidities, especially psychological, and their influence on smoking cessation is increasing. Genetic and neurological studies on factors that promote addiction are frequent too.

Regarding health, modern smokeless tobacco products such as the e-cigarette and their impact on health still need to be further investigated. Third hand smoke which refers to indirect exposure to tobacco smoke, sticking to clothes for example, and is inhaled, ingested and dermally absorbed is a further topic.

Second hand smoke exposure studies in outdoor locations such as cafés, bus stops and building entrances have been done but assessing health effects of these exposures is challenging.

Further topics related to tobacco research

The international anti-tobacco movement has been immensely successful in many directions during the past 20 years. Advertising on TV and in public places has disappeared to a large extent and sales to minors have been hampered. In Australia plain cigarette packaging reached a new climax in 2012 with a drab dark brown colour and no logo (173). Although most developing countries are far from such strict rules and some industrialized countries such as Switzerland are still in the middle of what seems like a long adaptation phase, the future-oriented research community is debating what its ultimate goal in this battle actually is. A worldwide smoking ban? Make tobacco illegal? A non-hazardous cigarette?

Countries with more or less comprehensive smoking bans will certainly continue to rise in number. The question remains how many exceptions and loop holes will continue to be written into these laws.

Regarding policy, researchers are indeed discussing the "end game of tobacco": making the world tobacco-free. Despite there still being many countries without a comprehensive smoking ban there are some health advocates fighting for a complete prohibition of all tobacco products. New Zealand and Finland are leaders in this mission aiming for a smoke-free country by 2025 and 2040 respectively (174, 175) and Sweden is about to follow their example (176). One proposed strategy to achieve this is by applying a "sinking lid", eg. by prohibiting cigarette sales to anyone born after 2000. However, this could substantially increase illicit trade.

A major goal is the development of a clean cigarette with a reduced nicotine content that is potentially harmless and non-addictive. Banning certain additives such as menthol or clove is also under discussion. The tobacco industry missed the chance to develop a harmless cigarette being too focused on covering up and distorting unfavourable evidence from the scientific community.

Studies of the relationship between smoking and health risks have been important in establishing the basis of observational epidemiological studies and causal inferences. This methodology may be applied to other risk factors and to better understand the causality of NCDs (177). Parallels have been found between the tobacco industries' and the food industries' strategies, so lessons learned from tobacco research may apply in other sectors as well (178).

9.6 Conclusion

In this study we confirmed the need for a comprehensive smoking ban in Switzerland to effectively protect hospitality workers' cardiovascular health. Only a law without exceptions will be complied with and well accepted.

The Swiss government needs to free itself from the influence of the tobacco industry, ratify the Framework Convention for Tobacco Control and start implementing the recommendations therein on a national level without exceptions.

10 REFERENCES

1. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012 Dec 15;380(9859):2224-60. PubMed PMID: 23245609.

2. WHO Report on the Global Tobacco Epidemic 2008: The MPOWER Package. WHO, 2008.

3. Cigarette Smoking Among Adults --- United States. CDC, 2007.

4. Keller R, Radtke T, Krebs H, Hornung R. Der Tabakkonsum der Schweizer Wohnbevölkerung in den Jahren 2001 bis 2010. 2011.

5. The Health Consequences of Smoking: A Report of the Surgeon General. Reports of the Surgeon General. Atlanta (GA)2004.

6. Hukkanen J, Jacob P, 3rd, Benowitz NL. Metabolism and disposition kinetics of nicotine. Pharmacological reviews. 2005 Mar;57(1):79-115. PubMed PMID: 15734728.

7. US Department of Health and Human Services. 2010.

8. Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012 Dec 15;380(9859):2197-223. PubMed PMID: 23245608.

9. Vital Signs. Tobacco Use. CDC, 2010.

10. Hoch E, Muehlig S, Hofler M, Lieb R, Wittchen HU. How prevalent is smoking and nicotine dependence in primary care in Germany? Addiction. 2004 Dec;99(12):1586-98. PubMed PMID: WOS:000225791000016. English.

11. Die Sucht und ihre Stoffe: Nikotin. In: (DHS) DHfSeV, editor. 2010.

12. Smith CJ, Sears SB, Walker JC, DeLuca PO. Environmental tobacco smoke: current assessment and future directions. Toxicologic pathology. 1992;20(2):289-303; discussion -5. PubMed PMID: 1475591.

13. Schutz der Familie vor Tabakrauch. . Heidelberg: Deutsches Krebsforschungszentrum; 2010.

14. Schick S, Glantz SA. Sidestream cigarette smoke toxicity increases with aging and exposure duration. Tobacco control. 2006 Dec;15(6):424-9. PubMed PMID: 17130369. Pubmed Central PMCID: 2563675.

15. IARC monographs on the evaluation of carcinogenic risks to humans: Volume 83. Tobacco smoke and involuntary smoking. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2004.

16. The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General. Publications and Reports of the Surgeon General. Atlanta (GA)2006.

17. Richter E, Scherer G. Aktives und passives Rauchen. In: H. M, SG. S, editors. Lehrbuch der Toxikologie. Stuttgart: Wissenschaftliche Verlagsgesellschaft mbH; 2004.

18. The Health consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General. U.S. Department of Health and Human Services, 2006.

19. Secondhand Smoke and Cancer. National Cancer Institute; 2011.

20. Huss A, Kooijman C, Breuer M, Bohler P, Zund T, Wenk S, et al. Fine particulate matter measurements in Swiss restaurants, cafes and bars: what is the effect of spatial separation between smoking and non-smoking areas? Indoor air. 2010 Feb;20(1):52-60. PubMed PMID: 19958392. Epub 2009/12/05. eng.

21. Factsheet No. 339: Tobacco. WHO, 2012.

22. Global Estimate of the Burden of Disease from Second-hand Smoke. WHO, 2010.

23. Bolte G, Fromme H, Group GMES. Socioeconomic determinants of children's environmental tobacco smoke exposure and family's home smoking policy. European journal of public health. 2009 Jan;19(1):52-8. PubMed PMID: 19033356.

24. Roosli M. Non-cancer effects of chemical agents on children's health. Progress in biophysics and molecular biology. 2011 Dec;107(3):315-22. PubMed PMID: 21906619.

25. Leonardi-Bee J, Britton J, Venn A. Secondhand smoke and adverse fetal outcomes in nonsmoking pregnant women: a meta-analysis. Pediatrics. 2011 Apr;127(4):734-41. PubMed PMID: 21382949.

26. Salmasi G, Grady R, Jones J, McDonald SD, Knowledge Synthesis G. Environmental tobacco smoke exposure and perinatal outcomes: a systematic review and meta-analyses. Acta obstetricia et gynecologica Scandinavica. 2010;89(4):423-41. PubMed PMID: 20085532.

27. Lee CY, Glantz SA. The Tobacco Industry’s Successful Efforts to Control Tobacco Policy Making in Switzerland. University of California, 2001.

28. www.lungenliga.ch: Lungenliga; 2013.

29. Fontham ET, Correa P, WuWilliams A, Reynolds P, Greenberg RS, Buffler PA, et al. Lung cancer in nonsmoking women: a multicenter case-control study. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology. 1991 Nov-Dec;1(1):35-43. PubMed PMID: 1845167.

30. http://en.wikipedia.org/wiki/Spirometry: Wikipedia; 2013.

31. Pierce R. Spirometry: an essential clinical measurement. Australian family physician. 2005 Jul;34(7):535-9. PubMed PMID: 15999163.

32. Alving K, Malinovschi A. Chapter 1. Basic aspects of exhaled nitric oxide. 2010.

33. ATS/ERS recommendations for standardized procedures for the online and offline measurement of exhaled lower respiratory nitric oxide and nasal nitric oxide, 2005. American journal of respiratory and critical care medicine. 2005 Apr 15;171(8):912-30. PubMed PMID: 15817806. Epub 2005/04/09. eng.

34. Kharitonov SA, Robbins RA, Yates D, Keatings V, Barnes PJ. Acute and chronic effects of cigarette smoking on exhaled nitric oxide. American journal of respiratory and critical care medicine. 1995 Aug;152(2):609-12. PubMed PMID: 7543345. Epub 1995/08/01. eng.

35. Law MR, Wald NJ. Environmental tobacco smoke and ischemic heart disease. Progress in cardiovascular diseases. 2003 Jul-Aug;46(1):31-8. PubMed PMID: 12920699.

36. Pechacek TF, Babb S. How acute and reversible are the cardiovascular risks of secondhand smoke? BMJ. 2004 Apr 24;328(7446):980-3. PubMed PMID: 15105323. Pubmed Central PMCID: 404492.

37. Kleiger RE, Bigger JT, Bosner MS, Chung MK, Cook JR, Rolnitzky LM, et al. Stability over time of variables measuring heart rate variability in normal subjects. The American journal of cardiology. 1991 Sep 1;68(6):626-30. PubMed PMID: 1877480.

38. http://eleceng.dit.ie/tburke/biomed/assignment1.html: Ted Burke; 2007.

39. Rajendra Acharya U, Paul Joseph K, Kannathal N, Lim CM, Suri JS. Heart rate variability: a review. Medical & biological engineering & computing. 2006 Dec;44(12):1031-51. PubMed PMID: 17111118.

40. Nolan J, Batin PD, Andrews R, Lindsay SJ, Brooksby P, Mullen M, et al. Prospective study of heart rate variability and mortality in chronic heart failure: results of the United Kingdom heart failure evaluation and assessment of risk trial (UK-heart). Circulation. 1998 Oct 13;98(15):1510-6. PubMed PMID: 9769304.

41. de Bruyne MC, Kors JA, Hoes AW, Klootwijk P, Dekker JM, Hofman A, et al. Both decreased and increased heart rate variability on the standard 10-second electrocardiogram predict cardiac mortality in the elderly: the Rotterdam Study. American journal of epidemiology. 1999 Dec 15;150(12):1282-8. PubMed PMID: 10604770.

42. Dekker JM, Schouten EG, Klootwijk P, Pool J, Swenne CA, Kromhout D. Heart rate variability from short electrocardiographic recordings predicts mortality from all causes in middle-aged and elderly men. The Zutphen Study. American journal of epidemiology. 1997 May 15;145(10):899-908. PubMed PMID: 9149661.

43. Thayer JF, Sternberg E. Beyond heart rate variability: vagal regulation of allostatic systems. Annals of the New York Academy of Sciences. 2006 Nov;1088:361-72. PubMed PMID: 17192580.

44. Boutouyrie P, Briet M, Collin C, Vermeersch S, Pannier B. Assessment of pulse wave velocity. Artery Research. 2009;3(1):3-8.

45. Nichols WW. Clinical measurement of arterial stiffness obtained from noninvasive pressure waveforms. American journal of hypertension. 2005 Jan;18(1 Pt 2):3S-10S. PubMed PMID: 15683725.

46. A Counterblaste to Tobacco. King James I of England; 1604.

47. Radford RA. The Economic Organisation of a P.O.W. Camp. Economica. 1945;12(48):189-201.

48. Eriksen M, Mackay J, Ross H. The Tobacco Atlas. Fourth Ed. Atlanta GA: American Cancer Society; New York NY; World Lung Foundation, 2012.

49. Ochsner A, DeBakey M. Primary Pulmonary malignancy. Surg Gynecol Obstet. 1939.

50. Doll R, Hill AB. Smoking and carcinoma of the lung. Preliminary report. BMJ. 1950.

51. Doll R, Gray R, Hafner B, Peto R. Mortality in relation to smoking: 22 years' observations on female British doctors. British medical journal. 1980 Apr 5;280(6219):967-71. PubMed PMID: 7417764. Pubmed Central PMCID: 1601142.

52. Doll R, Peto R. Mortality in relation to smoking: 20 years' observations on male British doctors. British medical journal. 1976 Dec 25;2(6051):1525-36. PubMed PMID: 1009386. Pubmed Central PMCID: 1690096.

53. Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. BMJ. 2004 Jun 26;328(7455):1519. PubMed PMID: 15213107. Pubmed Central PMCID: 437139.

54. Doll R, Peto R, Wheatley K, Gray R, Sutherland I. Mortality in relation to smoking: 40 years' observations on male British doctors. BMJ. 1994 Oct 8;309(6959):901-11. PubMed PMID: 7755693. Pubmed Central PMCID: 2541142.

55. Doll R, Hill AB. The mortality of doctors in relation to their smoking habits. BMJ. 1954.

56. 1st Surgeon General Report: Smoking and Health. 1964.

57. Syamlal G, Mazurek J, Malarcher A. Current Cigarette Smoking Prevalence Among Working Adults --- United States, 2004--2010. Weekly. 2011;60(38):1305-9.

58. Cataldo JK, Malone RE. False promises: the tobacco industry, "low tar" cigarettes, and older smokers. Journal of the American Geriatrics Society. 2008 Sep;56(9):1716-23. PubMed PMID: 18691279. Pubmed Central PMCID: 2788397.

59. Hyland A, Barnoya J, Corral JE. Smoke-free air policies: past, present and future. Tobacco control. 2012 Mar;21(2):154-61. PubMed PMID: 22345239.

60. Sebrie EM, Barnoya J, Perez-Stable EJ, Glantz SA. Tobacco industry successfully prevented tobacco control legislation in Argentina. Tobacco control. 2005 Oct;14(5):e2. PubMed PMID: 16183967. Pubmed Central PMCID: 1748093.

61. Barnoya J, Glantz SA. The tobacco industry's worldwide ETS consultants project: European and Asian components. European journal of public health. 2006 Feb;16(1):69-77. PubMed PMID: 16076855.

62. Barnoya J, Glantz SA. The tobacco industry and secondhand smoke: lessons from Central and South America. Ethnicity & disease. 2003 Summer;13(2 Suppl 2):S88-90. PubMed PMID: 13677420.

63. Barnoya J, Glantz S. Tobacco industry success in preventing regulation of secondhand smoke in Latin America: the "Latin Project". Tobacco control. 2002 Dec;11(4):305-14. PubMed PMID: 12432156. Pubmed Central PMCID: 1747685.

64. Public Health Cigarette Smoking Act of 1969. Tobaccodocuments.org; 1969.

65. Hirayama T. Non-smoking wives of heavy smokers have a higher risk of lung cancer: a study from Japan. Br Med J (Clin Res Ed). 1981 Jan 17;282(6259):183-5. PubMed PMID: 6779940. Pubmed Central PMCID: 1503989.

66. Constitution of the World Health Organization, (1948).

67. WHO Framework Convention on Tobacco Control. 2003.

68. http://www.who.int/fctc/text_download/en/index.html: WHO; 2013.

69. http://www.who.int/tobacco/en/index.html: WHO; 2013.

70. Bachinger E, McKee M, Gilmore A. Tobacco policies in Nazi Germany: not as simple as it seems. Public health. 2008 May;122(5):497-505. PubMed PMID: 18222506. Pubmed Central PMCID: 2441844.

71. Drope J, Bialous SA, Glantz SA. Tobacco industry efforts to present ventilation as an alternative to smoke-free environments in North America. Tobacco control. 2004 Mar;13 Suppl 1:i41-7. PubMed PMID: 14985616. Pubmed Central PMCID: 1766145.

72. Dearlove JV, Bialous SA, Glantz SA. Tobacco industry manipulation of the hospitality industry to maintain smoking in public places. Tobacco control. 2002 Jun;11(2):94-104. PubMed PMID: 12034999. Pubmed Central PMCID: 1763854.

73. Mullally BJ, Greiner BA, Allwright S, Paul G, Perry IJ. The effect of the Irish smoke-free workplace legislation on smoking among bar workers. European journal of public health. 2009 Apr;19(2):206-11. PubMed PMID: 19307250. Pubmed Central PMCID: 2720734.

74. Buonanno P, Ranzani M. Thank you for not smoking: evidence from the Italian smoking ban. Health policy. 2013 Feb;109(2):192-9. PubMed PMID: 23148891.

75. Health Act. HM Government; The National Archives; 2006.

76. Smokefree Status of Workplaces and Hospitality Venues Around the World; Americans for Nonsmokers' Rights; 2013.

77. Bundesgesetz vom 3. Oktober 2008 zum Schutz vor Passivrauchen (SR 818.31), (2008).

78. Verordnung vom 28. Oktober 2009 zum Schutz vor Passivrauchen (Passivrauchschutzverordnung, PaRV) (SR 818.311), (2009).

79. Lüthi N. „Zum Nichtrauchen bitte vor die Tür!“: Die baselstädtische Vereinslösung im Kontext der Gesetzgebung zum Schutz vor Passivrauchen im Gastgewerbe 2011.

80. Eidgenössische Volksinitiative «Schutz der Gesundheit vor dem Passivrauchen – Für einen effektiv wirksamen und nicht diskriminierenden Schutz gemäss den Normen der WHO». In: Chancellery F, editor.: The Federal Authorities of the Swiss Confederation; 2012.

81. Blecher E, van Walbeek C. An Analysis of Cigarette Affordability. Paris: International Union Against Tuberculosis and Lung Disease, 2008.

82. http://www.bag.admin.ch/themen/drogen/00041/00612/01748/: Eidgenössisches Departement des Inneren EDI; 2012.

83. Verordnung über den Tabakpräventionsfonds (TPFV). The Federal Authorities of the Swiss Confederation; 2004.

84. National Tobacco Programme 2008-2016. Federal Office of Public Health, 2012.

85. Hauri DD, Lieb CM, Rajkumar S, Kooijman C, Sommer HL, Roosli M. Direct health costs of environmental tobacco smoke exposure and indirect health benefits due to smoking ban introduction. European journal of public health. 2011 Jun;21(3):316-22. PubMed PMID: 20929904.

86. Smoking-attributable mortality in Switzerland. Neuchatel: Swiss Federal Statistical Office, 2009.

87. Huynh CK, Moix J, Dubuis A. [Development and application of the passive smoking monitor MoNIC]. Revue Médicale Suisse. 2008;4(144):430-3. French.

88. Huynh CK, Moix J-B, Dubuis A, Varonier HS, Stauffer Babel R, Celio M, et al. Second Hand Tobacco Smoke exposure in Switzerland. CHUV Research Day2009. p. 26.

89. WHO. Guidelines for Controlling and Monitoring the Tabacco Epidemic. Geneva1998.

90. Durham AD, Bergier S, Morisod X, Locatelli I, Zellweger JP, Huynh CK, et al. Improved health of hospitality workers after a Swiss cantonal smoking ban. Swiss medical weekly. 2011;141:w13317. PubMed PMID: 22252843. Epub 2012/01/19. eng.

91. Eisner MD, Smith AK, Blanc PD. Bartenders' respiratory health after establishment of smoke-free bars and taverns. JAMA : the journal of the American Medical Association. 1998 Dec 9;280(22):1909-14. PubMed PMID: 9851475. Epub 1998/12/16. eng.

92. Fernandez E, Fu M, Pascual JA, Lopez MJ, Perez-Rios M, Schiaffino A, et al. Impact of the Spanish smoking law on exposure to second-hand smoke and respiratory health in hospitality workers: a cohort study. PloS one. 2009;4(1):e4244. PubMed PMID: 19165321. Pubmed Central PMCID: 2621339. Epub 2009/01/24. eng.

93. Goodman P, Agnew M, McCaffrey M, Paul G, Clancy L. Effects of the Irish smoking ban on respiratory health of bar workers and air quality in Dublin pubs. American journal of respiratory and critical care medicine. 2007 Apr 15;175(8):840-5. PubMed PMID: 17204724.

94. Lai HK, Hedley AJ, Repace J, So C, Lu QY, McGhee SM, et al. Lung function and exposure to workplace second-hand smoke during exemptions from smoking ban legislation: an exposure-response relationship based on indoor PM2.5 and urinary cotinine levels. Thorax. 2011 Jul;66(7):615-23. PubMed PMID: 21551212. Epub 2011/05/10. eng.

95. Anthony JC, Echeagaray-Wagner F. Epidemiologic analysis of alcohol and tobacco use. Alcohol research & health : the journal of the National Institute on Alcohol Abuse and Alcoholism. 2000;24(4):201-8. PubMed PMID: 15986714.

96. Bolte G, Heitmann D, Kiranoglu M, Schierl R, Diemer J, Koerner W, et al. Exposure to environmental tobacco smoke in German restaurants, pubs and discotheques. Journal of exposure science & environmental epidemiology. 2008 May;18(3):262-71. PubMed PMID: 17565353.

97. Keller R, Radtke T, Krebs H, Hornung R. Tabakmonitoring: Passivrauchen in der Schweizer Bevölkerung 2010. 2011.

98. Jarvis MJ, Foulds J, Feyerabend C. Exposure to passive smoking among bar staff. British journal of addiction. 1992 Jan;87(1):111-3. PubMed PMID: 1543931.

99. Allwright S, Paul G, Greiner B, Mullally BJ, Pursell L, Kelly A, et al. Legislation for smoke-free workplaces and health of bar workers in Ireland: before and after study. Bmj. 2005 Nov 12;331(7525):1117. PubMed PMID: 16230313.

100. Benowitz NL. Biomarkers of environmental tobacco smoke exposure. Environmental health perspectives. 1999 May;107 Suppl 2:349-55. PubMed PMID: 10350520. Pubmed Central PMCID: 1566286.

101. Al-Delaimy WK. Hair as a biomarker for exposure to tobacco smoke. Tobacco Control. 2002 Sep;11(3):176-82. PubMed PMID: 12198265. Pubmed Central PMCID: 1759008. Epub 2002/08/29. eng.

102. Hammond SK, Leaderer BP. A diffusion monitor to measure exposure to passive smoking. Environmental science & technology. 1987 May 1;21(5):494-7. PubMed PMID: 22296139.

103. Ogden MW, Maiolo KC. Comparative Evaluation of Diffusive and Active Sampling Systems for Determining Airborne Nicotine and 3-Ethenylpyridine. Environmental science & technology. 1992 1992/06/01;26(6):1226-34.

104. Erazo M, Iglesias V, Droppelmann A, Acuna M, Peruga A, Breysse PN, et al. Secondhand tobacco smoke in bars and restaurants in Santiago, Chile: evaluation of partial smoking ban legislation in public places. Tobacco control. 2010 Dec;19(6):469-74. PubMed PMID: 20798021. Pubmed Central PMCID: 2991072. Epub 2010/08/28. eng.

105. Barnoya J, Arvizu M, Jones MR, Hernandez JC, Breysse PN, Navas-Acien A. Secondhand smoke exposure in bars and restaurants in Guatemala City: before and after smoking ban evaluation. Cancer causes & control : CCC. 2011 Jan;22(1):151-6. PubMed PMID: 21046446. Epub 2010/11/04. eng.

106. Bohac DL, Hewett MJ, Kapphahn KI, Grimsrud DT, Apte MG, Gundel LA. Change in indoor particle levels after a smoking ban in Minnesota bars and restaurants. American journal of preventive medicine. 2010 Dec;39(6 Suppl 1):S3-9. PubMed PMID: 21074674. Epub 2010/11/16. eng.

107. Apsley A, Semple S. Secondhand smoke levels in Scottish bars 5 years on from the introduction of smoke-free legislation. Tobacco control. 2011 Oct 20. PubMed PMID: 22016506. Epub 2011/10/22. Eng.

108. Villarroel N, Lopez MJ, Sanchez-Martinez F, Fernandez E, Nebot M. [Second-hand smoke exposure in hospitality venues in Barcelona: measurement of respirable particles]. Gaceta sanitaria / SESPAS. 2011 May-Jun;25(3):220-3. PubMed PMID: 21339029. Epub 2011/02/23. Exposicion al humo ambiental de tabaco en locales de hosteleria de Barcelona: medicion de particulas respirables. spa.

109. Reijula JP, Johnsson TS, Kaleva PS, Reijula KE. Exposure to tobacco smoke and prevalence of symptoms decreased among Finnish restaurant workers after the smoke-free law. American journal of industrial medicine. 2012 Jan;55(1):37-43. PubMed PMID: 21882216. Epub 2011/09/02. eng.

110. Jensen JA, Schillo BA, Moilanen MM, Lindgren BR, Murphy S, Carmella S, et al. Tobacco smoke exposure in nonsmoking hospitality workers before and after a state smoking ban. Cancer epidemiology, biomarkers & prevention. 2010 Apr;19(4):1016-21. PubMed PMID: 20354127. Pubmed Central PMCID: 2859032. Epub 2010/04/01. eng.

111. Wintour P. MPs to challenge ministers' veto on total smoking ban. The Guardian. 2005.

112. Martinez-Sanchez JM, Blanch C, Fu M, Gallus S, La Vecchia C, Fernandez E. Do smoke-free policies in work and public places increase smoking in private venues? Tobacco control. 2013 Apr 25. PubMed PMID: 23619245.

113. Willemsen MC, Kiselinova M, Nagelhout GE, Joossens L, Knibbe RA. Concern about passive smoking and tobacco control policies in European countries: an ecological study. BMC public health. 2012;12:876. PubMed PMID: 23067145. Pubmed Central PMCID: 3519676.

114. Schoj V, Alderete M, Ruiz E, Hasdeu S, Linetzky B, Ferrante D. The impact of a 100% smoke-free law on the health of hospitality workers from the city of Neuquen, Argentina. Tobacco control. 2010 Apr;19(2):134-7. PubMed PMID: 20378587. Pubmed Central PMCID: 2989166.

115. Brandli O, Schindler C, Kunzli N, Keller R, Perruchoud AP. Lung function in healthy never smoking adults: reference values and lower limits of normal of a Swiss population. Thorax. 1996 Mar;51(3):277-83. PubMed PMID: 8779131. Pubmed Central PMCID: 1090639. Epub 1996/03/01. eng.

116. Castellsague J, Burgos F, Sunyer J, Barbera JA, Roca J. Prediction equations for forced spirometry from European origin populations. Barcelona Collaborative Group on Reference Values for Pulmonary Function Testing and the Spanish Group of the European Community Respiratory Health Survey. Respiratory medicine. 1998 Mar;92(3):401-7. PubMed PMID: 9692096. Epub 1998/08/06. eng.

117. Kuster SP, Kuster D, Schindler C, Rochat MK, Braun J, Held L, et al. Reference equations for lung function screening of healthy never-smoking adults aged 18-80 years. The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology. 2008 Apr;31(4):860-8. PubMed PMID: 18057057. Epub 2007/12/07. eng.

118. Dressel H, de la Motte D, Reichert J, Ochmann U, Petru R, Angerer P, et al. Exhaled nitric oxide: independent effects of atopy, smoking, respiratory tract infection, gender and height. Respiratory medicine. 2008 Jul;102(7):962-9. PubMed PMID: 18396030. Epub 2008/04/09. eng.

119. Matsunaga K, Hirano T, Kawayama T, Tsuburai T, Nagase H, Aizawa H, et al. Reference ranges for exhaled nitric oxide fraction in healthy Japanese adult population. Allergology international : official journal of the Japanese Society of Allergology. 2010 Dec;59(4):363-7. PubMed PMID: 20864792. Epub 2010/09/25. eng.

120. Karrasch S, Ernst K, Behr J, Heinrich J, Huber RM, Nowak D, et al. Exhaled nitric oxide and influencing factors in a random population sample. Respiratory medicine. 2011 May;105(5):713-8. PubMed PMID: 21146387. Epub 2010/12/15. eng.

121. Nunan D, Sandercock GR, Brodie DA. A quantitative systematic review of normal values for short-term heart rate variability in healthy adults. Pacing and clinical electrophysiology : PACE. 2010 Nov;33(11):1407-17. PubMed PMID: 20663071.

122. Shirai K, Hiruta N, Song M, Kurosu T, Suzuki J, Tomaru T, et al. Cardio-ankle vascular index (CAVI) as a novel indicator of arterial stiffness: theory, evidence and perspectives. Journal of atherosclerosis and thrombosis. 2011;18(11):924-38. PubMed PMID: 21628839. Epub 2011/06/02. eng.

123. Nadif R, Matran R, Maccario J, Bechet M, Le Moual N, Scheinmann P, et al. Passive and active smoking and exhaled nitric oxide levels according to asthma and atopy in adults. Annals of allergy, asthma & immunology : official publication of the American College of Allergy, Asthma, & Immunology. 2010 May;104(5):385-93. PubMed PMID: 20486328. Epub 2010/05/22. eng.

124. Ayres JG, Semple S, MacCalman L, Dempsey S, Hilton S, Hurley JF, et al. Bar workers' health and environmental tobacco smoke exposure (BHETSE): symptomatic improvement in bar staff following smoke-free legislation in Scotland. Occupational and environmental medicine. 2009 May;66(5):339-46. PubMed PMID: 19208693. Epub 2009/02/12. eng.

125. Menzies D, Nair A, Williamson PA, Schembri S, Al-Khairalla MZ, Barnes M, et al. Respiratory symptoms, pulmonary function, and markers of inflammation among bar workers before and after a legislative ban on smoking in public places. JAMA : the journal of the American Medical Association. 2006 Oct 11;296(14):1742-8. PubMed PMID: 17032987. Epub 2006/10/13. eng.

126. Pope CA, 3rd, Eatough DJ, Gold DR, Pang Y, Nielsen KR, Nath P, et al. Acute exposure to environmental tobacco smoke and heart rate variability. Environmental health perspectives. 2001 Jul;109(7):711-6. PubMed PMID: 11485870. Pubmed Central PMCID: 1240375. Epub 2001/08/04. eng.

127. Chen CY, Chow D, Chiamvimonvat N, Glatter KA, Li N, He Y, et al. Short-term secondhand smoke exposure decreases heart rate variability and increases arrhythmia susceptibility in mice. American journal of physiology Heart and circulatory physiology. 2008 Aug;295(2):H632-9. PubMed PMID: 18552155. Pubmed Central PMCID: 2519230. Epub 2008/06/17. eng.

128. Felber Dietrich D, Gemperli A, Gaspoz JM, Schindler C, Liu LJ, Gold DR, et al. Differences in heart rate variability associated with long-term exposure to NO2. Environmental health perspectives. 2008 Oct;116(10):1357-61. PubMed PMID: 18941578. Pubmed Central PMCID: 2569095.

129. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Circulation. 1996 Mar 1;93(5):1043-65. PubMed PMID: 8598068.

130. Wu CF, Kuo IC, Su TC, Li YR, Lin LY, Chan CC, et al. Effects of personal exposure to particulate matter and ozone on arterial stiffness and heart rate variability in healthy adults. American journal of epidemiology. 2010 Jun 15;171(12):1299-309. PubMed PMID: 20507901. Epub 2010/05/29. eng.

131. Robbins RA, Millatmal T, Lassi K, Rennard S, Daughton D. Smoking cessation is associated with an increase in exhaled nitric oxide. Chest. 1997 Aug;112(2):313-8. PubMed PMID: 9266863. Epub 1997/08/01. eng.

132. Bessa V, Tseliou E, Bakakos P, Loukides S. Noninvasive evaluation of airway inflammation in asthmatic patients who smoke: implications for application in clinical practice. Annals of allergy, asthma & immunology : official publication of the American College of Allergy, Asthma, & Immunology. 2008 Sep;101(3):226-32; quiz 32-4, 78. PubMed PMID: 18814444. Epub 2008/09/26. eng.

133. du Prel JB, Hommel G, Rohrig B, Blettner M. Confidence interval or p-value?: part 4 of a series on evaluation of scientific publications. Deutsches Arzteblatt international. 2009 May;106(19):335-9. PubMed PMID: 19547734. Pubmed Central PMCID: 2689604.

134. Gratziou C, Lignos M, Dassiou M, Roussos C. Influence of atopy on exhaled nitric oxide in patients with stable asthma and rhinitis. The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology. 1999 Oct;14(4):897-901. PubMed PMID: 10573239. Epub 1999/11/26. eng.

135. Lopez MJ, Nebot M, Schiaffino A, Perez-Rios M, Fu M, Ariza C, et al. Two-year impact of the Spanish smoking law on exposure to secondhand smoke: evidence of the failure of the 'Spanish model'. Tobacco Control. 2011 Jun 9;21(4):407-11. PubMed PMID: 21659449. Epub 2011/06/11. Eng.

136. Hyland A, Higbee C, Borland R, Travers M, Hastings G, Fong GT, et al. Attitudes and beliefs about secondhand smoke and smoke-free policies in four countries: findings from the International Tobacco Control Four Country Survey. Nicotine & tobacco research : official journal of the Society for

Research on Nicotine and Tobacco. 2009 Jun;11(6):642-9. PubMed PMID: 19454550. Pubmed Central PMCID: 2688606.

137. Borland R, Yong HH, Siahpush M, Hyland A, Campbell S, Hastings G, et al. Support for and reported compliance with smoke-free restaurants and bars by smokers in four countries: findings from the International Tobacco Control (ITC) Four Country Survey. Tobacco control. 2006 Jun;15 Suppl 3:iii34-41. PubMed PMID: 16754945. Pubmed Central PMCID: 2593054.

138. Fong GT, Hyland A, Borland R, Hammond D, Hastings G, McNeill A, et al. Reductions in tobacco smoke pollution and increases in support for smoke-free public places following the implementation of comprehensive smoke-free workplace legislation in the Republic of Ireland: findings from the ITC Ireland/UK Survey. Tobacco control. 2006 June 1, 2006;15(suppl_3):iii51-8.

139. Goodman PG, Haw S, Kabir Z, Clancy L. Are there health benefits associated with comprehensive smoke-free laws. International journal of public health. 2009;54(6):367-78. PubMed PMID: 19882106.

140. Meyers DG, Neuberger JS, He J. Cardiovascular effect of bans on smoking in public places: a systematic review and meta-analysis. Journal of the American College of Cardiology. 2009 Sep 29;54(14):1249-55. PubMed PMID: 19778665.

141. Wuthrich B. [Epidemiology of allergies in Switzerland]. Therapeutische Umschau Revue therapeutique. 2001 May;58(5):253-8. PubMed PMID: 11407223. Epidemiologie der Allergien in der Schweiz.

142. Bang KM, Kim JH. Prevalence of cigarette smoking by occupation and industry in the United States. Am J Ind Med. 2001 Sep;40(3):233-9. PubMed PMID: 11598969.

143. Kogevinas M, Anto JM, Sunyer J, Tobias A, Kromhout H, Burney P. Occupational asthma in Europe and other industrialised areas: a population-based study. European Community Respiratory Health Survey Study Group. Lancet. 1999 May 22;353(9166):1750-4. PubMed PMID: 10347988.

144. McCurdy SA, Sunyer J, Zock JP, Anto JM, Kogevinas M, European Community Respiratory Health Survey Study G. Smoking and occupation from the European Community Respiratory Health Survey. Occupational and environmental medicine. 2003 Sep;60(9):643-8. PubMed PMID: 12937184. Pubmed Central PMCID: 1740626.

145. Armstrong BK, White E, Saracci R. Principles of Exposure Measurement in Epidemiology. Oxford: Oxford University Press; 1992.

146. Repace J. Flying the smoky skies: secondhand smoke exposure of flight attendants. Tobacco control. 2004 Mar;13 Suppl 1:i8-19. PubMed PMID: 14985612. Pubmed Central PMCID: 1766146.

147. Ebbert JO, Croghan IT, Schroeder DR, Murawski J, Hurt RD. Association between respiratory tract diseases and secondhand smoke exposure among never smoking flight attendants: a cross-sectional survey. Environmental health : a global access science source. 2007;6:28. PubMed PMID: 17897468. Pubmed Central PMCID: 2064907.

148. Arjomandi M, Haight T, Redberg R, Gold WM. Pulmonary function abnormalities in never-smoking flight attendants exposed to secondhand tobacco smoke in the aircraft cabin. Journal of occupational and environmental medicine / American College of Occupational and Environmental Medicine. 2009 Jun;51(6):639-46. PubMed PMID: 19448573. Pubmed Central PMCID: 2722845.

149. Pan J, Barbeau EM, Levenstein C, Balbach ED. Smoke-free airlines and the role of organized labor: a case study. American journal of public health. 2005 Mar;95(3):398-404. PubMed PMID: 15727966. Pubmed Central PMCID: 1449191.

150. Patel MX, Doku V, Tennakoon L. Challenges in recruitment of research participants. Advances in Psychiatric Treatment. 2003;9:229-38.

151. Shah D. Healthy worker effect phenomenon. Indian journal of occupational and environmental medicine. 2009 Aug;13(2):77-9. PubMed PMID: 20386623. Pubmed Central PMCID: 2847330.

152. Guidelines for Ethics Committees. New Zealand: Health Research Council of New Zealand (HRC).

153. NHMRC Statement on human experimentation. National Health and Medical Research Council of Australia; 1992.

154. FDA Information Sheet: Payment of Research Subjects. Rockville, United States: Food and Drug Administration; 1988.

155. Bower P, Wallace P, Ward E, Graffy J, Miller J, Delaney B, et al. Improving recruitment to health research in primary care. Family practice. 2009 Oct;26(5):391-7. PubMed PMID: 19549623.

156. Scollo M, Lal A, Hyland A, Glantz S. Review of the quality of studies on the economic effects of smoke-free policies on the hospitality industry. Tobacco control. 2003 Mar;12(1):13-20. PubMed PMID: 12612356. Pubmed Central PMCID: 1759095.

157. Lal A, Siahpush M, Scollo M. The economic impact of smoke-free legislation on sales turnover in restaurants and pubs in Tasmania. Tobacco control. 2004 Dec;13(4):454-5. PubMed PMID: 15564637. Pubmed Central PMCID: 1747923.

158. Pakko MR. Smoke-free law did affect revenue from gaming in Delaware. Tobacco control. 2006 Feb;15(1):68-9; author reply 9. PubMed PMID: 16436409. Pubmed Central PMCID: 2563623.

159. Glantz SA, Smith LR. The effect of ordinances requiring smoke-free restaurants on restaurant sales. American journal of public health. 1994 Jul;84(7):1081-5. PubMed PMID: 8017529. Pubmed Central PMCID: 1614757.

160. Schulz PJ, Hartung U, Fiordelli M. Effect of smoke-free legislation on Ticino gastronomy revenue. International journal of public health. 2012 Dec;57(6):861-6. PubMed PMID: 22941112.

161. Bilir N, Ozcebe H. Success of Tobacco Control in Turkey: Role of Government Approach and Civil Society Support. Society for Research on Nicotine and Tobacco; Boston2013.

162. Gesundheitskosten Schweiz im Überblick. Santé Suisse, 2009.

163. Hunziker H-U. Report on passive smoking in Switzerland. In: Zeltner T, editor. San Francisco: Legacy Tobacco Documents Library; 1996.

164. Diethelm P, McKee M. Lifting the smokescreen. Tobacco industry strategy to defeat smoke free policies and legislation. Brussels: European Respiratory Society and Institut National du Cancer (INCa, France), 2006.

165. Rylander R. Respiratory infection in children, ETS exposure, social factors and diet (abstract ATS). American Thoracic Society Conference1992.

166. Basisinformation zur Tabakwerbung. Bern: Federal Office of Public Health FOPH, 2007.

167. Cornuz J, Burnand B, Kawachi I, Gutzwiller F, Paccaud F. Why did Swiss citizens refuse to ban tobacco advertising? Tobacco control. 1996 Summer;5(2):149-53. PubMed PMID: 8910998. Pubmed Central PMCID: 1759508.

168. WHO policy on non-recruitment of smokers or other tobacco users, (2008).

169. Hesse D. No Smokers! Der Bund. 2013 1 May 2013.

170. Leppo K, Ollila E, Peña S, Wismar M, Cook S. Health in All Policies. Seizing opportunities, implementing policies. Finland: Ministry of Social Affairs and Health; 2013.

171. Best Practices for Comprehensive Tobacco Control Programs—2007. Atlanta: Centers for Disease Control and Prevention, 2007.

172. Lee PN, Fry JS. Reassessing the evidence relating smoking bans to heart disease. Regulatory toxicology and pharmacology : RTP. 2011 Dec;61(3):318-31. PubMed PMID: 21945743. Epub 2011/09/29. eng.

173. Tobacco Plain Packaging Bill 2011. Parliament of Australia; 2011.

174. Levy DT, Blackman K, Currie LM, Levy J, Clancy L. SimSmokeFinn: how far can tobacco control policies move Finland toward tobacco-free 2040 goals? Scandinavian journal of public health. 2012 Aug;40(6):544-52. PubMed PMID: 22899560.

175. Smokefree 2025 http://smokefree.org.nz/smokefree-2025: Health Promotion Agency; [27 May 2013].

176. Landes D. Total smoking ban in Sweden by 2025. The Local. Sweden's news in English. 2013 13 March 2013.

177. Beaglehole R, Ebrahim S, Reddy S, Voute J, Leeder S, Chronic Disease Action G. Prevention of chronic diseases: a call to action. Lancet. 2007 Dec 22;370(9605):2152-7. PubMed PMID: 18063026.

178. Dorfman L, Cheyne A, Friedman LC, Wadud A, Gottlieb M. Soda and tobacco industry corporate social responsibility campaigns: how do they compare? PLoS medicine. 2012;9(6):e1001241. PubMed PMID: 22723745. Pubmed Central PMCID: 3378589.

11 APPENDIX - ARTICLE 5: Direct health costs of environmental tobacco smoke exposure and indirect health benefits due to smoking ban introduction

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Direct health costs of environmental tobacco smoke exposure and indirect health benefits due to smoking ban introduction

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Background: Introducing comprehensive smoke-free policies to public places is expected to reduce health costs. This includes prevented health damages by avoiding environmental tobacco smoke (ETS) exposure as well as indirect health benefits from reduced tobacco consumption. **Methods:** The aim of this study was to estimate direct health costs of ETS exposure in public places and indirect health benefits from reduced tobacco consumption. We calculated attributable hospital days and years of life lost (YLL), based on the observed passive smoking and disease rates in Switzerland. The exposure–response associations of all relevant health outcomes were derived by meta-analysis from prospective cohort studies in order to calculate the direct health costs. To assess the indirect health benefits, a meta-analysis of smoking ban studies on hospital admissions for acute myocardial infarction was conducted. **Results:** ETS exposure in public places in Switzerland causes 32 000 preventable hospital days (95% CI: 10 000–61 000), 3000 YLL (95% CI: 1000–5000), corresponding to health costs of 330 Mio CHF. The number of hospital days for ischaemic heart disease attributable to passive smoking is much larger if derived from smoking ban studies (41 000) than from prospective cohort studies (3200), resulting in additional health costs of 89 Mio CHF, which are attributed to the indirect health benefits of a smoking ban introduction. **Conclusion:** The example of smoking ban studies on ischaemic heart disease hospitalization rates suggests that total health costs that can be prevented with smoking bans are considerably larger than the costs arising from the direct health impact of ETS exposure in public places.

Keywords: attributable cases, health care costs, life expectancy, smoking ban, tobacco smoke pollution

Introduction

During the past years, comprehensive smoke-free policies for public places have been introduced in various countries (France, Ireland, Italy, the UK, parts of the USA and Canada). Other countries (Switzerland, Germany or Japan) do not have comprehensive smoking bans.[1–3] The introduction of smoking bans for public places resulted in a reduction of environmental tobacco smoke (ETS) exposure of hospitality workers[4,5] as well as of the general population.[6,7]

Beside reduction of ETS exposure, studies demonstrated that the introduction of smoking bans in public places and workplaces were followed by a reduction of the tobacco consumption in many countries, such as Italy,[8] the USA, Australia, Canada and Germany.[9]

After the introduction of smoking bans, regional studies in Europe and North America found reductions of hospital admissions due to myocardial infarctions.[10–12]

Such smoking ban studies have the advantage of not only considering the direct health effects from ETS exposure, but also the indirect health effects that accompany the introduction of a smoking ban such as the reduction of tobacco consumption of smokers. These indirect benefits are also relevant for policy decision makers in order to estimate the total health benefits associated with the introduction of a comprehensive smoke-free policy. However, these indirect benefits are not captured by conventional health impact assessments (HIA) that quantify only the direct health consequences of passive smoking based on exposure–response associations between health outcomes and ETS exposure derived from epidemiological studies.

To our knowledge, smoking ban studies have not been used for HIA, so far, to estimate direct and indirect preventable health costs when introducing a smoking ban. Therefore, our aim is to estimate the direct health costs related to ETS exposure in public places in Switzerland from available epidemiological research and additionally by evaluating indirect preventable health costs by considering the results of recently published smoking ban studies.

Methods

Selection of the health effects

All health outcomes with sufficient or suggestive causal relationship to ETS exposure according to the Surgeon General report were considered relevant for this HIA *a priori*.[13] From these, we did not consider health effects for which health costs cannot be determined (e.g. annoyance). In addition, we only included clearly delimitable health effects in order to avoid double counts. Breast cancer was excluded because we found no increased risk in a meta-analysis of prospective cohort studies. Finally, we were left with the following outcomes: ischaemic heart disease, stroke, lung cancer, nasal sinus cancer, chronic obstructive pulmonary disease (COPD), asthma, hospital admissions due to respiratory diseases and preterm delivery.

Derivation of the exposure–response associations

The exposure–response associations between ETS exposure and the selected health outcomes were derived from epidemiologic literature. For lung cancer and ischaemic heart disease, we carried out a systematic literature review including a meta-analysis. For all other health effects, we derived the exposure–response association by meta-analysis from all studies mentioned in the Surgeon General report[13] or we used newer peer reviewed meta-analyses in the case of stroke.[14,15]

We only considered prospective cohort studies as they are not prone to recall bias and generally assumed to be most reliable. In addition, we considered smoking ban studies in order to evaluate indirect health benefits of smoking ban introduction on ischaemic heart disease hospitalization rates.

In our systematic review of lung cancer and ischaemic heart disease studies, we searched EMBASE and MEDLINE to identify relevant studies published prior to 2009. From each publication, data were independently extracted by two experienced epidemiologists using structured data extraction sheets. To be considered for inclusion, the relevant studies had to be in English or German and had to be carried out in Europe, North America, Japan, South Korea, Australia and New Zealand, since these regions represent most adequately the Swiss situation in terms of exposure. Relevant studies had to quantify the ETS exposure as well as the exposure–response associations including measure of precision (e.g. confidence interval). In addition, selected studies had to be peer reviewed. If several publications were available from the same cohort, we only considered the most comprehensive data analysis. We excluded studies that were solely done in patients. We calculated separate effect estimates for YLL and hospital days' calculation based on incidence (morbidity) and/or mortality studies. Depending on the heterogeneity between the studies, we used random or fixed effect models for our meta-analyses.

Determination of the ETS exposure

In the framework of our research question, we only considered ETS exposure in public places (restaurants, cafes, bars, events, workplaces, schools and universities). We took into account data on ETS exposure for the year 2006 when no smoke-free policies had been implemented on a compulsory base in Switzerland. Public transport had introduced a smoking ban in trains at the end of 2005.

Data on the ETS exposure of the Swiss population were obtained from the Swiss tobacco monitoring, which is carried out on behalf of the Federal Office of Public Health every 3 months, since 2001.[16,17] It is a representative survey among 2500 persons in Switzerland aged between 14 and 65 years. We used the data from the fourth quarter of 2006 to calculate the cumulative exposure time per week for all type of public places including work places. For the age group >65 years, we used the data from the age group 55–65 years but excluded ETS exposure at workplace.

For our HIA, we assumed that ETS exposure of >7 h a week at public places is approximately the same as living with a smoker. This is the typical exposure status of exposed study participants in prospective cohort studies.

Observed health frequencies

For all morbidity outcomes except preterm delivery, we calculated the attributable hospital days as this is particularly relevant for the cost estimates. Age-specific numbers of hospital days were obtained for each relevant diagnosis using the number of stationary cases and the average length of stay of the year 2006 from the medical statistics of Swiss hospitals.[18] Mortality data for the YLL calculation were derived from the official Swiss mortality statistics of the year 2006.[19]

Calculation of attributable cases

For our calculation, we used a hypothetical scenario with a smoking ban in force, i.e. no ETS exposure at public places. Thus the expected number of hospital days for the hypothetical scenario (N_h) is obtained from the observed number of hospital days (N_o) the following way:

$$N_h = \frac{N_o}{RR_{exp}} \quad (1)$$

where,

$$RR_{exp} = P_{not\ exposed} + (P_{exposed} \cdot RR) \quad (2)$$

RR is the exposure response association of ETS exposure, and P is the proportion of the population exposed or not exposed, respectively. Smoking ban studies are based on the whole population, and thus do not require knowledge about the exposure distribution of the target population. Thus, the number of expected hospital days after the introduction of a smoking ban is obtained from the pooled risk estimate of the smoking ban studies (RR_{ban}) the following way:

$$N_h = N_o \cdot RR_{ban} \quad (3)$$

To obtain the hospital days attributable to passive smoking, we subtracted the expected number of hospital days of the hypothetical scenario (N_h) from the observed number of hospital days. Since ETS exposure and the observed health frequencies are age dependent, we calculated all attributable cases for three different age groups separately (15–39, 40–69, ≥70 years) and added them up.

Calculation of the YLL

YLL were calculated using the method described in Miller and Hurley[20,21] for fatal health outcomes (ischaemic heart diseases, stroke, lung cancer, nasal sinus cancer and COPD). We calculated life tables using the observed hazard rates for the reference scenario and the modified hazard rates without ETS exposure for the hypothetical scenario without ETS exposure at public places. For the reference scenario, we applied the observed age-specific mortality rates to project and estimate the age-specific number of deaths for every fatal health outcome in each year until the year 2100 and computed the number of life years using a cohort life table. The same procedure was applied with modified survival functions reflecting the absence of ETS exposure. Calculations were done for 10-year age categories reflecting the exposure situation and relative risk of the corresponding age groups. We also took into account a time lag between ETS exposure and health impact (latency of 13 years for carcinogenic diseases, 1.5 years for cardiovascular disease[22] and 2 years for COPD).[23]

Determination of the health costs

The health costs consist of medical treatment costs (hospital days), costs due to net loss of production, the costs of reoccupation due to death of an employee and the immaterial costs that comprise the costs for pain and suffering. The cost rates and their sources are given in table A1.

Medical treatment costs were determined for each health outcome separately from the All Patient Diagnosis Related Groups (APDRG) Suisse.[24] The data of the APDRG Suisse are based on a sample of 290 000 hospitalizations, collected between 2001 and 2003.

The costs due to net loss of production arise from work absence of adults (between 17 and 65 years). Work absence was assumed to be doubled as long as the stay at the hospital, as it was done in other impact assessments.[25–27] Unlike costs per case of illness, costs per day due to net loss of production are independent of the disease and the same costs per hospital day were used for all health outcomes. Net production loss of a YLL corresponds to a full year of work absence, which is CHF 49 000.[28]

The immaterial costs were estimated by the willingness to pay method. Immaterial costs of a hospital day were determined from a Californian survey that is based on a sample of 394 persons of a median age of 67 years.[29] The cost rate, published in this study, lies between those of two European studies.[27,30] In this study, cost rates for hospital days were not different according to diagnosis. The cost rate for the immaterial costs of an YLL corresponds to the value of a life year lost (VLYL), which is independent from the age structure of the concerned people. Since there are no estimations for VLYL, the VLYL are derived from the discounted sum of the YLL. Thereby a discount rate of 2% was used. This procedure was also applied in several projects of the European Union (UNITE, HEATCO, IMPACT)[31–33] and in other Swiss health impact assessment.[26]

For preterm delivery, the additional costs compared to a normal birth are considered. These costs are also provided by the APDRG Suisse.[24]

In order to estimate the health costs that can be prevented by the introduction of a smoking ban, estimated cost rates for every health outcome were multiplied with the attributable cases and YLL. We also took into account the costs of ETS exposure in 2006 which arose after 2006. Thereby, the YLL were multiplied with a discount rate of 1%, considering a discount rate of 2% but corrected by the real wage growth.

Results

In 2006, 21% of the Swiss population were exposed to ETS in public places for >7 h a week. Exposure was highest in 20- to 24-year-old people (53%) decreasing with increasing age (Supplementary table S1).

In our systematic review, the pooled effect estimate of ETS exposure for ischaemic heart disease morbidity was 1.17 (95% CI: 1.12–1.23) based on 10 prospective studies on ischaemic heart disease morbidity and mortality (Supplementary figure S1), 1.17 (95% CI: 1.12–1.22) for ischaemic heart disease mortality based on 8 prospective cohort studies (Supplementary figure S2), 1.63 (95% CI: 1.29–2.04) for lung cancer morbidity based on four prospective studies (Supplementary figure S3) and 1.36 (95% CI: 1.17–1.58) for lung cancer mortality based on five prospective studies (Supplementary figure S4). Table A2 gives an overview on all effect estimates obtained from meta-analyses.

Combining relative risks from prospective cohort studies with observed hospital days (table A2) and the number of exposed individuals yields the direct health consequences of ETS exposure. In total, exposure to ETS in public places in Switzerland results in approximately 32 000 (95% CI: 10 000–61 000) additional hospital days and 179 (95% CI: 0–682) preterm deliveries (table A3). Life table calculations yielded about 3000 YLL (95% CI: 1500–5000) due to ETS exposure in public places, mainly owing to lung cancer [1500 (95% CI: 700–2300)] and ischaemic heart disease [1000 (95% CI: (700–1300)].

Overall, the direct health consequences from ETS exposure in public places causes health costs of 330 Mio CHF thereof 129 Mio CHF are attributable to lung cancer and 93 Mio CHF are attributable to ischaemic heart disease (table A3).

Indirect health benefits from smoking bans are evaluated with smoking ban studies. The introduction of a smoking ban reduced hospital admissions for ischaemic heart disease by 0.84 (95% CI: 0.80–0.88) (Supplementary figure S5). Estimating hospital admissions for ischaemic heart disease from smoking ban studies instead of prospective cohort studies results in 13 times higher number of estimated attributable cases, because the relative risk reduction is relevant to the whole population and not only to the exposed proportion (table A4). Hence, health costs due to ischaemic heart disease morbidity are 89 Mio CHF in addition to the conventional HIA of 8 Mio CHF based on prospective cohort studies.

Using the effect estimate for hospital admissions for ischaemic heart disease derived from smoking ban studies instead of the one from prospective cohort studies to estimate the number of YLL due to ischaemic heart disease mortality would result in a 16 times higher estimate (YLL = 15 000; 95% CI: 11 000–20 000), and hence health costs due to ischaemic heart disease would almost amount to 1.5 billion CHF (table A4).

Discussion

In 2006, 21% of the Swiss population were exposed to ETS for at least 7 h/week. This caused 32 000 hospital days (95% CI: 10 000–61 000), 3000 YLL (95% CI: 1500–5000) and thus direct health consequences of ETS exposure correspond to 330 Mio CHF in health costs. Smoking ban studies on hospital admissions due to ischaemic heart diseases suggest that an additional 38 000 hospital days corresponding to 89 Mio CHF can be avoided if a comprehensive smoking ban is introduced.

Our estimates of the direct health consequences of passive smoking tended to be somewhat lower than in similar studies from Spain and the UK. For instance, we estimated that 1.7% of all ischaemic heart disease deaths among people in working age (aged between 15 and 69 years) in Switzerland were due to ETS exposure (table A4).

In the UK, workplace-related ETS exposure was estimated to be responsible for 2.2% of all ischaemic heart disease deaths;[34] and in Spain, workplace-related ETS exposure was estimated to cause between 1.1% and 3.9% of all ischaemic heart disease deaths.[35]

For lung cancer, the attributable fractions were 3.4% in Switzerland, 2.6% in the UK and 2.1–12.3% in Spain. The main reason for our rather low estimates is the lower ETS exposure in our study. Whether this is a true difference between the three countries or whether exposure differences are due to different methods that were used to determine the proportion of the exposed population cannot be answered with the available information.

To our knowledge, this is the first HIA that takes into account smoking ban studies to estimate preventable health costs when introducing a smoking ban to public places.

Interestingly, compared with the conventional HIA approach that quantifies the direct health consequences of passive smoking based on prospective cohort studies, the consideration of smoking ban studies resulted in a much higher estimated number of preventable hospital days due to ischaemic heart disease. At a first glance, this substantial difference seems to be implausible because the relative risks of these studies are similar. A relative risk of 0.84 for smoking ban introduction corresponds quite well to the converse of the relative risk of the prospective cohort studies (1.18), which is the pooled effect estimate for persons being exposed to ETS at home from their partner. However, smoking ban studies are based on the whole population whereas prospective cohort studies express the risk only for a relatively small proportion of exposed persons. As a consequence, similar relative risks mean totally different number of attributable cases. Recently, Lightwood and Glantz[36] demonstrated that the results of the smoking ban studies are compatible with the prospective cohort studies if one assumes that the introduction of comprehensive smoke-free policies reduces tobacco consumption and results in quitting smokers as observed in various countries.[8,9] It was demonstrated among Japanese women and men that 1 year after having quit smoking, the relative risk of cardiovascular disease was reduced by 19%.[37]

The indirect health benefit of a smoking ban on smokers is supported by 2 smoking ban studies with separate analyses for smokers and non-smokers, which found similar relative reduction rates in hospital admissions for acute myocardial infarction for smokers and non-smokers.[7,38] Hence, the introduction of smoking bans in public places could also help to reduce health costs due to active smoking that are assumed to be much higher than the costs resulting from the direct health consequences of ETS exposure.

Unfortunately, smoking ban studies are not eligible for investigating long-term effects such as lung cancer and thus the studies available to date have only addressed acute effects on ischaemic heart disease hospitalization rates. Thus, indirect health benefits of smoking ban introduction can only be quantified for this outcome. If one applied the effect estimate for hospitalization rates also on ischaemic heart disease mortality to estimate the YLL, the fraction of ischaemic heart disease mortality attributable to ETS exposure would be much higher (16.5%) and the corresponding health cost estimates would exceed 1 billion CHF (table A4). This demonstrates that the indirect health benefits of a smoking ban introduction may be considerably higher than the direct health benefits from avoiding ETS exposure in public places.

Nevertheless, the extent of the direct and the indirect health benefits depend on the type of smoke-free policy. The more comprehensive a smoking ban is implemented, the more health benefits are expected. Smoking ban studies were mainly conducted in countries with comprehensive smoke-free policies such as Scotland, Ireland and Italy. In Switzerland, a few regions have introduced smoke-free policies since 2006. But most of these regulations allow exceptions like separate smoking rooms in restaurants. Similarly, the national law on the protection from ETS exposure, which will come into force on 1 May 2010, allows several exceptions as smoking will be still allowed in restaurants with a total square footage of up to 80 m^2 and customers are also served in smoking lounges. A measurement campaign in Swiss hospitality venues demonstrated that fine particulate matter concentrations (PM2.5) in non-smoking rooms of restaurants that allow smoking in a separate room are more than twice as high as in venues were smoking is not allowed at all. This reduces the direct health benefits from a smoking ban.[39] Possibly, smoke-free policies with many exceptions such as the national law in Switzerland from the 1st May 2010 have little impact on tobacco consumption and the quitting rates among smokers. This also reduces indirect health benefits of smoking ban introduction. Actually, this hypothesis is in line with the result of a recent small smoking ban study from one Swiss region where declined acute myocardial infarction hospitalization rates were observed in non-smokers but not in smokers.[12]

In conclusion, our HIA based on smoking ban studies suggests that the prevented health costs from introducing a smoking ban are considerably larger than what would be expected from the ETS exposure alone, because indirect health benefits in smokers have been demonstrated as well. The extent of these indirect effects, however, depends on the type of smoke-free regulation. The more widespread smoking is removed from the public places, the more health benefits can be expected.

Supplementary Data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Key points

- This is the first HIA which takes into account smoking ban studies to estimate preventable health costs when introducing a smoking ban to public places.
- Our study captures not only the direct effects of ETS exposure on myocardial infarction, but also indirect health benefits due to the introduction of smoking bans in public places such as the reduction of tobacco consumption in smokers.
- This study suggests that these indirect effects are even more public health relevant than the direct exposure effects.
- The extent of these indirect effects depends on the type of smoke-free regulation. The more widespread smoking is removed from public places, the more health benefits can be expected.

References

1 Goodman PG, Haw S, Kabir Z, Clancy L. Are there health benefits associated with comprehensive smoke-free laws. *Int J Public Health* 2009;54:367–78.

2 Koh HK, Joossens LX, Connolly GN. Making smoking history worldwide. *N Engl J Med* 2007;356:1496–8.

3 Spinney L. Public smoking bans show signs of success in Europe. *Lancet* 2007;369:1507–8.

4 Farrelly MC, Nonnemaker JM, Chou R, et al. Changes in hospitality workers' exposure to secondhand smoke following the implementation of New York's smoke-free law. *Tob Control* 2005;14:236–41.

5 Valente P, Forastiere F, Bacosi A, et al. Exposure to fine and ultrafine particles from secondhand smoke in public places before and after the smoking ban, Italy 2005. *Tob Control* 2007;16:312–7.

6 Haw SJ, Gruer L. Changes in exposure of adult non-smokers to secondhand smoke after implementation of smoke-free legislation in Scotland: National cross sectional survey. *BMJ* 2007;335:549–52.

7 Pell JP, Haw S, Cobbe S, et al. Smoke-free legislation and hospitalizations for acute coronary syndrome. *N Engl J Med* 2008;359:482–91.

8 Cesaroni G, Forastiere F, Agabiti N, et al. Effect of the Italian smoking ban on population rates of acute coronary events. *Circulation* 2008;117:1183–8.

9 Fichtenberg CM, Glantz SA. Effect of smoke-free workplaces on smoking behaviour: systematic review. *BMJ* 2002;325:188–91.

10 Barone-Adesi F, Vizzini L, Merletti F, Richiardi L. Short-term effects of Italian smoking regulation on rates of hospital admission for acute myocardial infarction. *Eur Heart J* 2006;27:2468–72.

11 Sargent RP, Shepard RM, Glantz SA. Reduced incidence of admissions for myocardial infarction associated with public smoking ban: Before and after study. *BMJ* 2004;328:977–80.

12 Trachsel LD, Kuhn MU, Reinhart WH, et al. Reduced incidence of acute myocardial infarction in the first year after implementation of a public smoking ban in Graubuenden, Switzerland. *Swiss Med Wkly* 2010;140:133–8.

13 U.S. Department of Health and Human Services. *The Health Consequences of Involuntary Exposure to Tobacco Smoke - A Report of the Surgeon General.* Atlanta, GA, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2006.

14 Heuschmann PU, Heidrich J, Wellmann J, et al. Stroke mortality and morbidity attributable to passive smoking in Germany. *Eur J Cardiovasc Prev Rehabil* 2007;14:793–5.

15 Lee PN, Forey BA. Environmental tobacco smoke exposure and risk of stroke in nonsmokers: a review with meta-analysis. *J Stroke Cerebrovasc Dis* 2006;15:190–201.

16 Radtke T, Krebs H, Keller R, Hornung R. Passivrauchen in der Schweizer Bevölkerung 2006 - Tabakmonitoring – Schweizerische Umfrage zum Tabakkonsum. [Second-hand smoke in Switzerland 2006 - Tobacco Monitoring – Swiss survey of tobacco consumption]. Zürich: Psychologisches Institut der Universität Zürich, Sozial- und Gesundheitspsychologie Zürich [Social and Health psychology at the Institute of Psychology, University of Zurich], 2007.

17 Radtke T, Krebs H, Keller R, Hornung R. Wöchentliche Gesamtpassivrauchexposition an öffentlichen Orten 2006 - Eine Zusatzauswertung im Rahmen des Tabakmonitoring Schweiz. Tabakmonitoring – Schweizerische Umfrage zum Tabakkonsum. [Weekly second-hand smoke exposure in public places 2006 – an additional evaluation within the Swiss tobacco monitoring. Tobacco Monitoring – Swiss survey of tobacco consumption] Zürich: Psychologisches Institut der Universität Zürich, Sozial- und Gesundheitspsychologie Zürich [Social and Health psychology at the Institute of Psychology, University of Zurich], 2009.

18 Swiss Federal Statistical Office. Available at: http://www.bfs.admin.ch/bfs/portal/de/index/themen/14/04/01/data/01.Document.104353.xls (3 September 2010, date last accessed).

19 Swiss Federal Statistical Office. *Statistik der Todesursachen und Totgeburten (eCOD) [Swiss statistics on the causes of death and dead births].* Neuchâtel, Switzerland, 2009.

20 Miller BG, Hurley JF. Life table methods for quantitative impact assessments in chronic mortality. *J Epidemiol Community Health* 2003;57:200–6.

21 Miller BG, Hurley JF. *Comparing Estimated Risks for Air Pollution with Risks for Other Health Effects.* Edinburgh, 2006. Report No.: TM/06/01.

22 Leksell I, Rabl A. Air pollution and mortality: quantification and valuation of years of life lost. *Risk Anal* 2001;21:843–57.

23 Röösli M, Künzli N, Braun-Fahrländer C, Egger M. Years of life lost attributable to air pollution in Switzerland: dynamic exposure-response model. *Int J Epidemiol* 2005;34:1029–35.

24 All Patient Diagnosis Related Groups (APDRG Suisse), Switzerland. Available at: http://www.apdrgsuisse.ch/public/de/o_rapport_cw_v51a_d.pdf (3 September 2010, date last accessed).

25 Ecoplan. Monetarisierung der verkehrsbedingten externen Gesundheitskosten. Synthesebericht, GVF-Auftrag Nr. 272. (Monetarisation of traffic-related external health costs. Synthesis report). Bern, 1996. GVF-cotract no. 272.

26 Federal Office for Spatial Development (ARE). Externe Gesundheitskosten durch verkehrsbedingte Luftverschmutzung in der Schweiz. Aktualisierung für das Jahr 2000 (External Health Costs due to Traffic Related Air Pollution in Switzerland). Updating for the year 2000. Bern, 2004.

27 Sommer H, Seethaler R, Chanel O, et al. *Health Costs due to Road Traffic-related Air Pollution, Technical Report on Economy.* Bern, 1999. GVF-contract no. 325.

28 Swiss Federal Statistical Office. *Statistisches Jahrbuch der Schweiz 2009 [Statistical Yearbook of Switzerland 2009].* Zurich, 2009a.

29 Chestnut LG, Thayer MA, Lazo JK, Van den Eeden S. The economic value of preventing respiratory and cardiovascular hospitalizations. *Contemporary Economic Policy* 2006;24:127–43.

30 Link H, Stewart LH, Doll C, et al. UNITE (UNIfication of accounts and marginal costs for Transport Efficiency) Working Funded by 5th Framework RTD Programme. Leeds: ITS, University of Leeds, 2002. Contract: 1999-AM.11157.

31 Bickel P, Hunt A, De Jon G, et al. HEATCO D5: Proposal for Harmonized Guidelines. Deliverable 5 of HEATCO (Developing Harmonized European Approaches for Transport Costing and Project Assessment). 2006. Contract No.: FP6-2002-SSP-1/502481.

32 INFRAS CD, Frauenhofer Gesellschaft ISI, University of Gdansk. IMPACT: Internalisation Measures and Policies for All external Cost of Transport. Deliverable 1: Handbook on estimation of external costs in the transport sector. Delft, Netherlands, 2007. Report No.: 07.4288.52.

33 Nellthorp J, Sansom T, Bickel P, et al. Valuation Convention for UNITE. UNITE (UNIfication of accounts and marginal costs for Transport Efficiency) Working Funded by 5th Framework RTD Programme. Leeds: ITS, University of Leeds, 2001. Contract No.: 1999-AM.11157.

34 Jamrozik K. Estimate of deaths attributable to passive smoking among UK adults: database analysis. *BMJ* 2005;330:812–5.

35 Lopez MJ, Perez-Rios M, Schiaffino A, et al. Mortality attributable to passive smoking in Spain, 2002. *Tob Control* 2007;16:373–7.

36 Lightwood JM, Glantz SA. Declines in acute myocardial infarction after smoke-free laws and individual risk attributable to secondhand smoke. *Circulation* 2009;120:1373–9.

37 Iso H, Date C, Yamamoto A, Toyoshima H, et al. Smoking cessation and mortality from cardiovascular disease among Japanese men and women: The JACC Study. *Am J Epidemiol* 2005;161:170–9.

38 Seo DC, Torabi MR. Reduced admissions for acute myocardial infarction associated with a public smoking ban: matched controlled study. *J Drug Educ* 2007;37:217–26.

39 Huss A, Kooijman C, Breuer M, et al. Fine particulate matter measurements in Swiss restaurants, cafés and bars: what is the effect of spatial separation between smoking and non-smoking areas? *Indoor Air* 2010;20:52–60.

40 Swiss Federal Statistical Office, Switzerland. Available at: http://www.bfs.admin.ch/bfs/portal/de/index/infothek/lexikon/bienvenue___login/blank/zugang_lexikon.Document.20851.xls (3 September 2010, date last accessed).

41 Ecoplan. Unfallkosten im Strassen- und Schienenverkehr der Schweiz 1998. Studie im Auftrag des Bundesamtes für Raumentwicklung (costs due to accidents in road and railway traffic in Switzerland 1998. Study on behalf of the Federal Department of the Environment, Transport, Energy and Communications (DETEC)). Altdorf, 2002.

Appendix 1

Table A1 Cost rates in CHF

	Medical treatment costs	Net production loss[a]	Immaterial costs	Total
Costs per hospital day				
Ischaemic heart disease	1453[b]	269[d]	814[c]	2535
Stroke	863[b]	269[d]	814[c]	1945
Lung cancer	911[b]	269[d]	814[c]	1993
Nasal sinus cancer	1386[b]	269[d]	814[c]	2468
Asthma	759[b]	269[d]	814[c]	1841
COPD	739[b]	269[d]	814[c]	1822
Other respiratory disease	1066[b]	269[d]	814[c]	2149
Additional costs due to preterm delivery	24 235[b]		n.a.	24 235
Costs per YLL				
All health end points		49 008[d]	93 567[e]	142 575
Reoccupation costs per death of an employee				28 009[f]

a: Net production loss is only calculated for employees, whereas all other costs are always taken into account. The cost rate per hospital day has been doubled to take into account the convalescence at home
b: Based on own evaluation of the APDRG Suisse (all patient diagnosis related groups)[24]
c: Based on Chestnut *et al.*, 2006[29]
d: Based on official statistics from Switzerland (Swiss Statistics)[28]
e: Based on €1.5 millions (1998 market prices) from the EU-project UNITE[33]
f: Based on official salary data (Swiss Statistics) and reoccupation costs of 50% of a yearly salary[40,41]
n.a. = not available.

Table A2 Observed hospital days, deaths and effect estimates, derived from meta-analyses of epidemiologic studies

Health effect	Observed frequencies	Effect estimate (95% CI)
Cardiovascular diseases		
Hospital days due to ischaemic heart disease (smoking ban introduction)	248 205	0.84 (0.80–0.88)
Hospital days due to ischaemic heart disease (prospective studies on ischaemic heart disease mortality and morbidity)		1.17 (1.12–1.23)
Death from ischaemic heart disease	9190	1.17 (1.12–1.22)
Hospital days due to stroke	208 958	1.14 (0.99–1.31)
Death from stroke	3320	1.14 (0.99–1.31)
Carcinogenic diseases		
Hospital days due to lung cancer	75 318	1.63 (1.29–2.04)
Death from lung cancer	2942	1.36 (1.17–1.58)
Hospital days due to breast cancer	63 951	1.01 (0.92–1.11)
Death from breast cancer (women)	1330	1.01 (0.92–1.11)
Hospital days due to nasal sinus cancer	472	2.06 (1.18–3.61)
Death from nasal sinus cancer (women)	8	2.06 (1.18–3.61)
Respiratory diseases		
Hospital days due to COPD	97 926	1.40 (1.10–1.77)
Death from COPD	1584	1.40 (1.10–1.77)
Hospital days due to asthma	35271	1.67 (0.88–3.17)
Hospital days due to other respiratory disease	338 515	1.56 (1.14–2.12)
Other diseases		
Number of preterm deliveries	6603	1.13 (0.83–1.53)

Table A3 Estimated hospital days, deaths, YLL and health costs, attributable to ETS (direct health effects)

Number of cases						Costs (Mio CHF)		
Health effect	Attributable hospital days				YLL total	Morbidity	YLL	Total
	15–39 years	40–69 years	≥70 years	Total				
Cardiovascular diseases								
Ischaemic heart disease	111 (79–143)	1836 (1297–2390)	1265 (892–1651)	3212 (2268–4184)	952 (660–1259)	7.68	85.38	93.06
Stroke	133 (0–290)	814 (0–1830)	1039 (0–2355)	1986 (0–4475)	219 (0–497)	3.52	19.50	23.02
Carcinogenic diseases								
Lung cancer	70 (36–106)	2323 (1123–3730)	1115 (532–1819)	3508 (1691–5655)	1453 (703–2312)	6.54	122.28	128.82
Nasal sinus cancer	5 (1–9)	23 (4–51)	11 (2–24)	39 (7–84)	11 (2–26)	0.09	0.90	0.99
Respiratory diseases								
Asthma	1369 (0–3280)	1244 (0–3537)	210 (0–630)	2823 (0–7447)		4.97	0	4.97
COPD	77 (21–136)	1265 (333–2375)	1309 (340–2493)	2651 (694–5004)	379 (98–729)	4.39	33.36	37.75
Other respiratory disease (without asthma, COPD)	7569 (2170–13 419)	5460 (1467–10 443)	5094 (1346–9949)	18 123 (4983–33 811)		36.74	0	36.74
Preterm delivery[a]				179 (0–682)				4.33
Total	9334 (2307–17 383)	12 965 (4224–24 356)	10 043 (3112–18 921)	32 342 (9643–60 660)	3014 (1463–4823)	63.93	261.42	329.68

a: not hospital days but number of preterm deliveries

Table A4 Estimated number of hospital days, deaths, YLL and health costs due to ischaemic heart disease: comparison of smoking ban studies and prospective cohort studies

Effect estimates			Number of cases									Costs (Mio CHF)		
Type of study	Morbidity	Mortality	Attributable hospital days				Attributable deaths				YLL total	Morbidity	YLL	Total
			15–39 years	15–69 years	≥70 years	total	15–39 years	15–69 years	≥70 years	Total				
Prospective cohort studies	1.17 (1.12–1.23)	1.17 (1.12–1.22)	111 (79–143)	1836 (1297–2390)	1265 (892–1651)	3212 (2268–4184)	1 (1–2)	20 (14–27)	72 (50–95)	93 (65–124)	952 (660–1259)	7.68	85.38	93.06
Smoking ban studies	0.84 (0.8–0.88)	0.84 (0.8–0.88)	399 (297–496)	18 313 (13 651–22 752)	22 242 (16 580–27 634)	40 954 (30 528–50 882)	5 (4–7)	208 (155–259)	1303 (971–1619)	1516 (1130–1885)	15 409 (11 144–19 738)	96.66	1372.24	1468.9

12 CURRICULUM VITAE

Name: Sarah Rajkumar

Date of birth: 7 October 1979
Nationalities: Swiss, British

Academic Experience

Colorado State University, Fort Collins, USA
Post-Doc in Epidemiology
2014-present

Swiss Tropical and Public Health Institute, associated institute to the University of Basel, Switzerland
PhD in Epidemiology
2009-2013

Swiss Federal Institute of Technology (ETH) Zurich, Switzerland
MSc, Biochemistry, 2000-2006
Diploma Subjects: Biochemistry, Cell Biology, Molecular Biology and Biophysics, Immunology, Food Microbiology

Kantonsschule Rychenberg, Winterthur, Switzerland
Matura Typus D, 1992-1999

Elective Adacemic Courses

Economics, University of Basel, 2012
International Relations, University of Basel, 2012
Project Management, University of Basel, 2011
Health Planning and Management in Settings with Limited Resources, Lugano Summer School, 2010

Professional Experience

Swiss Tropical and Public Health Institute, Swiss Center for International Health (SCIH), Switzerland
Scientific collaborator
2013- 2014

Child's Dream Cambodia, NGO for health and education, Cambodia
Volunteer
2009

Zurich Film Festival, Spoundation Motion Picture GmbH, Switzerland
Event Manager
2007

Novartis Pharma AG, Basel, Switzerland
Regulatory Assistant
2007

Short Term Contracts

Zurich Film Festival, Switzerland
Cablecom, Switzerland
UBS AG, Switzerland
2009

Novo Nordisk A/S, Switzerland
Assistant to the Vice President Human Resources & Communication
2008

Credit Suisse, Switzerland
"Business School" Administration
2006

KITAG Kino-Theater AG, Switzerland
2002 - 2007

Winterthur Swiss Insurance Company, Switzerland, Belgium, UK
Data Entry clerk
1999 - 2000

Volunteer Work

Anmesty International, Winterthur group
1995-2002
Nachbarschaftshilfe (neighbourly help), Zurich
2004
World Vision Switzerland
2000-2005

Language Skills

German	native
English	fluent
French	very good
Spanish	good

Publications

Hauri DD, Lieb CM, Rajkumar S, Kooijman C, Sommer HL, Roosli M. Direct health costs of environmental tobacco smoke exposure and indirect health benefits due to smoking ban introduction. European Journal of Public Health. 2011 Jun;21(3):316-22.

Rajkumar S, Huynh CK, Hoffmann S, Bauer GF, Röösli M. A novel method to estimate exposure reduction in hospitality workers after a smoking ban. BMC Public Health. 2013 Jun 4;13:536

Röösli M, Rajkumar S. How long is the yardstick for smoking bans in Switzerland? International Journal of Public Health. 2013 Dec;58(6):797-8.

Rajkumar S, Schmidt-Trucksäss A, Wellenius G, Bauer GF, Huynh CK, Moeller A, Röösli M. The effect of workplace smoking bans on heart rate variability and pulse wave velocity of non-smoking hospitality workers. International Journal of Public Health; 2014 Aug;59(4):577-85.

Rajkumar S, Hoffmann S, Bauer GF, Röösli M. Evaluation of implementation, compliance and acceptance of partial smoking bans among Swiss hospitality workers before and after the Swiss Tobacco Control Act. Journal of Public Health; 2014.

Rajkumar S, Hammer J, Moeller A, Stolz D, Bauer GF, Huynh CK, Röösli M The Effect of a Smoking Ban On Respiratory Health in Non-Smoking Hospitality Workers: A Prospective Cohort Study. Journal of Occupational and Environmental Medicine; 2014.

Conference Contributions

2011	Swiss Public Health Conference, Basel	oral presentation
	ISEE conference, Barcelona	poster presentation
	Deutsche Tabakpräventionskonferenz, Heidelberg	poster presentation
2012	Swiss Public Health Conference, Lausanne	oral presentation
	Deutsche Tabakpräventionskonferenz, Heidelberg	oral presentation
2013	SRNT Annual Meeting, Boston	poster presentation
	Swiss Public Health Conference, Zürich	poster presentation
	ISEE-ISES-ISIAQ Environment & Health Conference, Basel	oral presentation

Award

Swiss School of Public Health+ PhD Award 2012, Best Abstract

Teaching Activities

Swiss TPH: Key Issues in International Health; Tobacco- a burning public health issue, December 2012

ISSW, University of Basel: Wissenschaftliches Vorgehen zur Beurteilung der Qualität von Publikationen zum Tabakkonsum aus epidemiologischer Sicht, April 2013

COSIBAR