EPH109

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DECREASED SMOKING-ATTRIBUTABLE DEATHS IN GERMANY WITH SMOKE-FREE PRODUCTS AND TOBACCO CONTROL MEASURES: A MODELING STUDY

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Introduction

Smokers who completely switch from cigarettes to smoke-free products (SFPs) reduce their exposure to harmful and potentially harmful chemicals in cigarette smoke, which is expected to translate into a lower risk of smoking-related diseases including lung cancer (LC), ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), and stroke. We estimated the hypothetical population health impact of introducing SFPs (heated tobacco products [HTPs] and e-cigarettes [ECIGs]) and/or tobacco control measures (marketing ban, single price increase, plain packaging, minimum legal age [MLA] of 21) in Germany over 40 years (1995–2035).

Methods

The population health impact model (PHIM) was developed by Philip Morris Products S.A. to allow estimation of the potential reduction in smoking-attributable mortality due to the introduction of SFPs into a market or tobacco control measures. The basic method has been previously described [1] and applied to the US [2, 3], Japan [4], and Germany [5, 6].

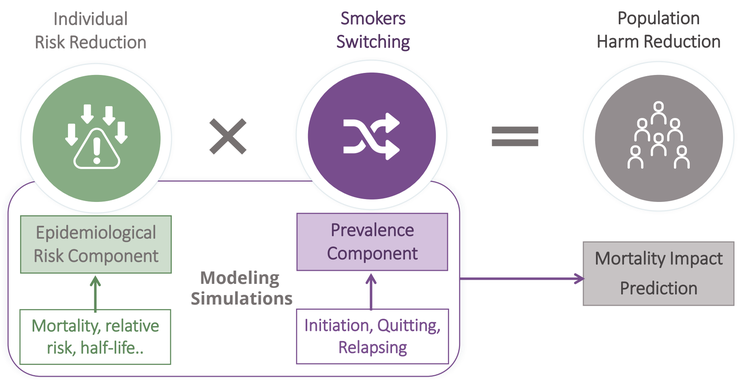

Fig. 1: The PHIM framework. The Epidemiological (E-) risk component uses the smoking histories produced by the prevalence (P-) component to estimate the mortality impact prediction.

Mortality impact prediction in PHIM involves two components:

❑ Prevalence Component

The prevalence (P-) component starts at the baseline year (1995), with a hypothetical population of males and females, with a defined cigarette smoking distribution. The population is then followed for 40 years under both the "NULL scenario" (no SFPs or control measures) and various "alternative scenarios" (introducing SFPs and/or control measures) using different sets of transition probabilities between product use groups.

Product use groups

Null and tobacco control scenarios (no SFPs):
Never users
Current exclusive cigarette smokers
Former cigarette smokers

Alternative scenarios (where SFPs are introduced):
Never users of any product
Current exclusive cigarette smokers
Current exclusive HTP users
Current exclusive ECIG users
Current multiple product users (two or three products)

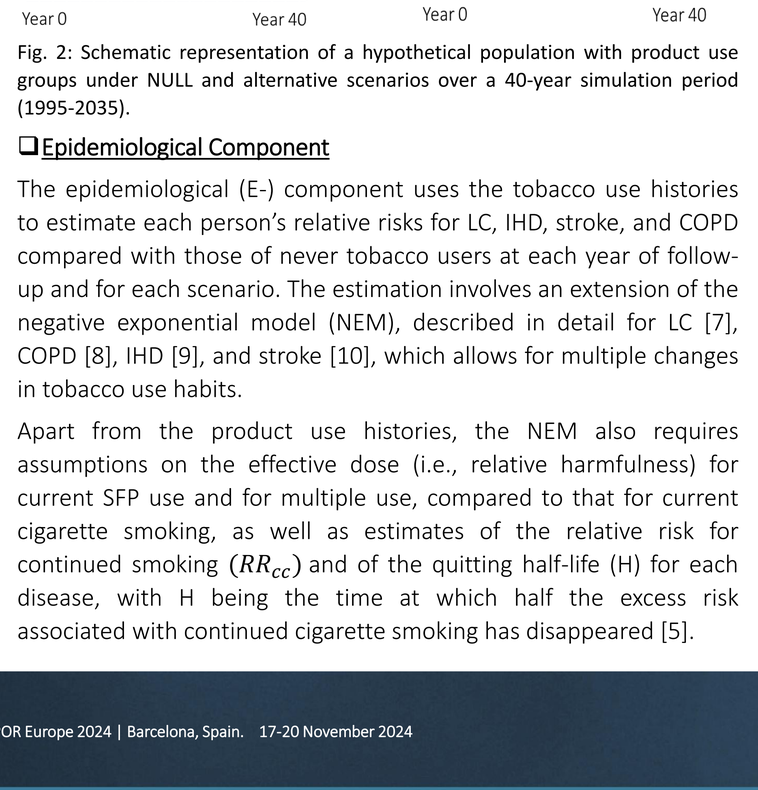

Fig. 2: Schematic representation of a hypothetical population with product use groups under NULL and alternative scenarios over a 40-year simulation period (1995-2035).

❑ Epidemiological Component

The epidemiological (E-) component uses the tobacco use histories to estimate each person's relative risks for LC, IHD, stroke, and COPD compared with those of never tobacco users at each year of follow-up and for each scenario. The estimation involves an extension of the negative exponential model (NEM), described in detail for LC [7], COPD [8], IHD [9], and stroke [10], which allows for multiple changes in tobacco use habits.

Apart from the product use histories, the NEM also requires assumptions on the effective dose (i.e., relative harmfulness) for current SFP use and for multiple use, compared to that for current cigarette smoking, as well as estimates of the relative risk for continued smoking (RR_{cc}) and of the quitting half-life (H) for each disease, with H being the time at which half the excess risk associated with continued cigarette smoking has disappeared [5].

For the alternative SFP scenario, the effective doses are assumed to be 0.2 for exclusive HTP use and 0.05 for exclusive ECIG use, in contrast to an effective dose of 1 for exclusive cigarette smoking. For multiple product use, it is assumed to be the mean of the three effective doses (i.e., 0.42) [5].

The NEM is used to calculate the excess relative risk over time t $(RR_t - 1)$ given the effective dose, the excess relative risk for a continuing cigarette smoker $(RR_{cc} - 1)$,and the disease-specific half-life of excess risk (H) [1]:

$$RR_t = 1 + (RR_{cc} - 1)\left(f + (1 - f)exp\left(\frac{-t\ ln(2)}{H}\right)\right)$$

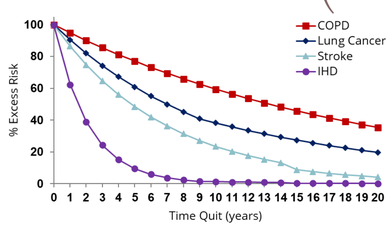

Fig. 3: Reduction in excess risk RR_t for four diseases as a function of time after quitting, as described by the NEM.

For each scenario, the average RR_t for each disease is calculated for individuals of a given sex and age group for each follow-up year, from which proportions of smoking-attributed deaths can be derived. These are converted to numbers using national mortality estimates (World Health Organization's Mortality Database) by sex, age group, and year.

Results

Twelve alternative scenarios simulated:

Extreme scenarios:

1. **Complete cessation**: In 1995, all current cigarette smokers immediately stop smoking.
2. **Complete switch to SFPs**: In 1995, all current cigarette smokers immediately switch to either HTPs or ECIGs with equal probability.

Pragmatic scenarios:

3. **Switching scenario**: The market shares in 2005 increase to 15.5% for HTPs and 36.4% for ECIGs of that in 1995 for cigarette smoking with 84% exclusive users for both SFPs.
4. **Full switching scenario**: The same as the switching scenario, except the proportion of exclusive users rise to 100% for both SFPs.

The implementation details for Extreme and Pragmatic scenarios are described earlier [5] .

Tobacco control scenarios (as described in [11]):

5. **Single price increase**: The single 10% price increase introduced in 1995 is assumed to produce a 2.5% relative reduction in prevalence in the first year.
6. **Marketing ban**: The market ban introduced in 1995 is assumed to produce a relative 5.0% reduction in prevalence in the first year.
7. **Plain packaging**: The introduction of plain packaging in 1995 is assumed to produce a relative 3.7% reduction in prevalence in the first year, an annual relative 1.7% reduction in the next 4 years.
8. **MLA 21**: The increase in the MLA from 18 to 21 years in 1995 is assumed to have an effect on initiation rates in younger individuals (shift by 3 years).

Combination scenarios:

9. Switching and single 10% price increase
10. Switching and marketing ban
11. Switching and plain packaging
12. Switching and MLA 21

Results: P-Component

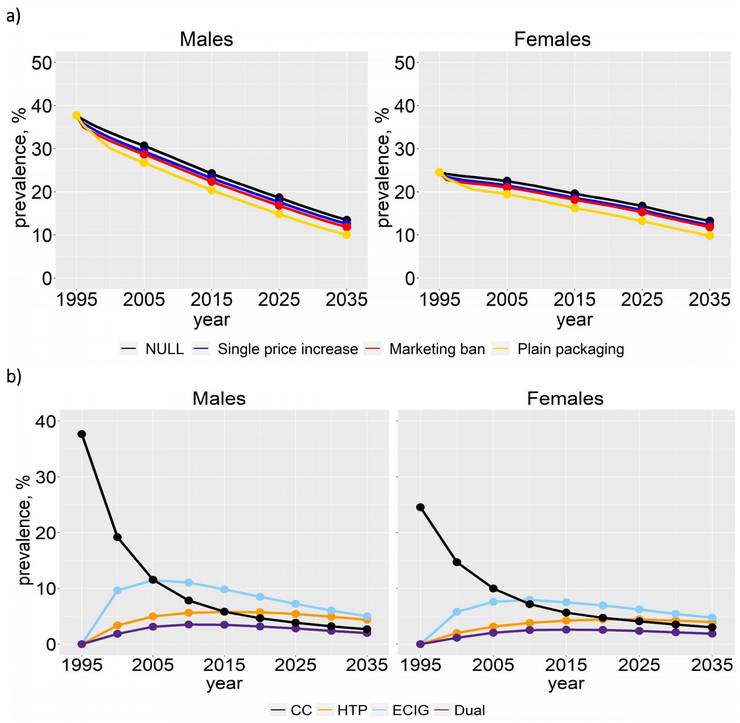

Fig. 4: Estimated smoking prevalence for the NULL and three tobacco control scenarios (5-8) by sex (a) and estimated product prevalences in the Switching scenario (b).

Results: E-Component

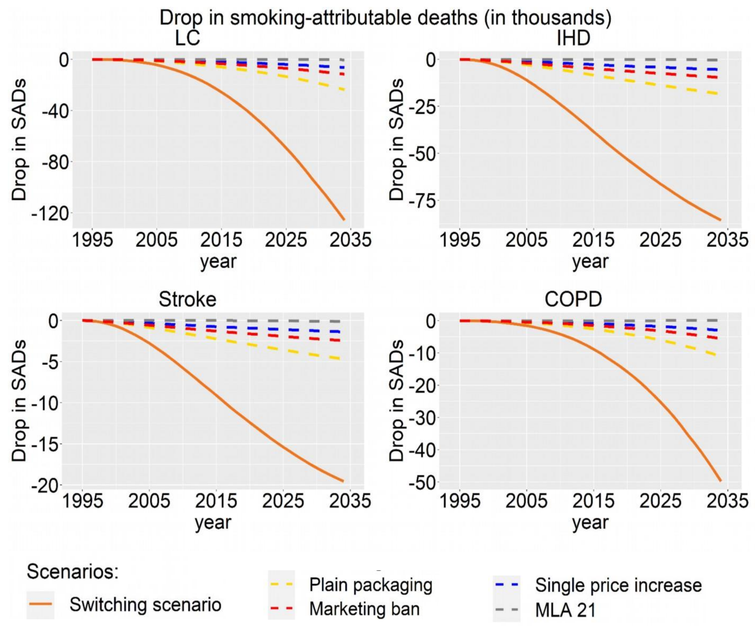

Fig. 5: Cumulative drops in smoking-attributable deaths (SADs) for the Switching (3) and tobacco control scenarios (5-8) over the follow-up period.

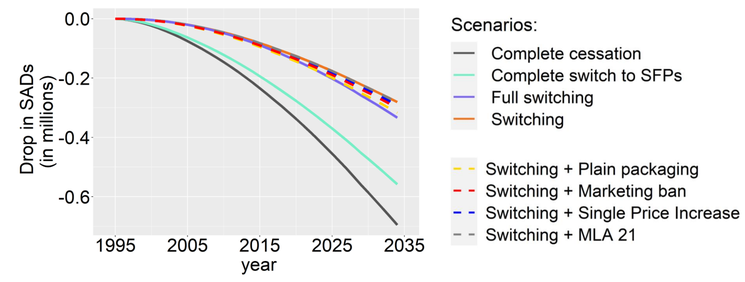

Fig. 6: Cumulative drops in smoking-attributable deaths (SADs) for alternative scenarios over the follow-up period.

Conclusions

Based on our assumptions, the results suggest that introducing SFPs into the German market in 1995 would potentially have led to substantial mortality reductions over the following 40 years in the evaluated scenarios. These reductions were hypothetically evaluated to be larger than those associated with introducing any of the four tobacco control measures considered.

Considering that both tobacco control measures and harm reduction tools can add value, future regulation should leverage both principles simultaneously.

References

1. Weitkunat, R., et al., *A novel approach to assess the population health impact of introducing a Modified Risk Tobacco Product.* Regul Toxicol Pharmacol, 2015. **72**(1): p. 87-93.
2. Djurdjevic, S., et al., *Modeling the Population Health Impact of Introducing a Modified Risk Tobacco Product into the U.S. Market.* Healthcare (Basel), 2018. **6**(2).
3. Lee, P.N., et al., *Estimating the effect of differing assumptions on the population health impact of introducing a Reduced Risk Tobacco Product in the USA.* Regul Toxicol Pharmacol, 2017. **88**: p. 192-213.
4. Lee, P.N., et al., *Estimating the population health impact of introducing a reduced-risk tobacco product into Japan. The effect of differing assumptions, and some comparisons with the U.S.* Regul Toxicol Pharmacol, 2018. **100**: p. 92-104.
5. Rytsar, R., et al., *Estimated Public Health Gains From German Smokers Switching to Reduced-Risk Alternatives: Results From Population Health Impact Modelling.* Contributions to Tobacco & Nicotine Research, 2022. **31**(1): p. 35-51.
6. Rytsar, R., et al., *Estimated Public Health Gains From Smokers in Germany Switching to Reduced-Risk Alternatives: Results From Population Health Impact Modelling by Socioeconomic Group.* Contributions to Tobacco & Nicotine Research, 2022. **31**(1): p. 52-67.
7. Fry, J.S., et al., *How rapidly does the excess risk of lung cancer decline following quitting smoking? A quantitative review using the negative exponential model.* Regul Toxicol Pharmacol, 2013. **67**(1): p. 13-26.
8. Lee, P.N., J.S. Fry, and B.A. Forey, *Estimating the decline in excess risk of chronic obstructive pulmonary disease following quitting smoking - a systematic review based on the negative exponential model.* Regul Toxicol Pharmacol, 2014. **68**(2): p. 231-9.
9. Lee, P.N., J.S. Fry, and J.S. Hamling, *Using the negative exponential distribution to quantitatively review the evidence on how rapidly the excess risk of ischaemic heart disease declines following quitting smoking.* Regul Toxicol Pharmacol, 2012. **64**(1): p. 51-67.
10. Lee, P.N., J.S. Fry, and A.J. Thornton, *Estimating the decline in excess risk of cerebrovascular disease following quitting smoking--a systematic review based on the negative exponential model.* Regul Toxicol Pharmacol, 2014. **68**(1): p. 85-95.
11. Gredner, T., et al., *Impact of Tobacco Control Policies on Smoking-Related Cancer Incidence in Germany 2020 to 2050-A Simulation Study.* Cancer Epidemiol Biomarkers Prev, 2020. **29**(7): p. 1413-1422.

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