Influence of Cigarette Filter Ventilation on Smokers' Mouth Level Exposure to Tar and Nicotine: A Retrospective Meta-Analysis of 11 Studies in 9 Countries

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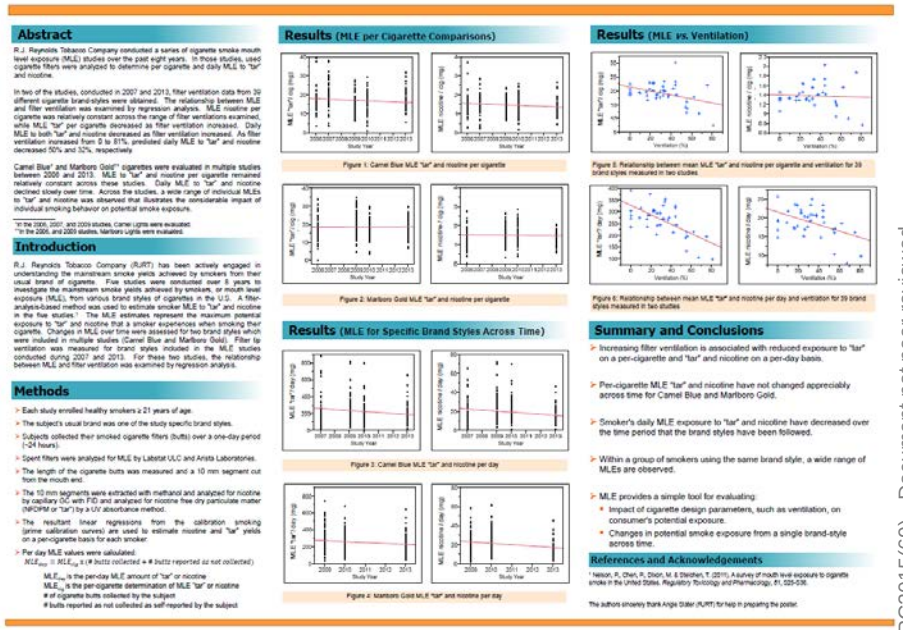
Background

68th Tobacco Science Research Conference



RETROSPECTIVE ANALYSIS OF DATA FROM CIGARETTE SMOKE MOUTH LEVEL EXPOSURE (MLE) STUDIES

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Abstract

R.J. Reynolds Tobacco Company conducted a series of cigarette smoke mouth level exposure (MLE) studies over the past eight years. In those studies, used cigarette filters were analyzed to determine per cigarette and daily MLE to "tar" and nicotine.

In two of the studies, conducted in 2007 and 2013, filter ventilation data from 39 different cigarette brand-styles were obtained. The relationship between MLE and filter ventilation was examined by regression analysis. MLE nicotine per cigarette was relatively constant across the range of filter ventilations examined, while MLE "tar" per cigarette decreased as filter ventilation increased. Daily MLE to both "tar" and nicotine decreased as filter ventilation increased. As filter ventilation increased from 0 to 81%, predicted daily MLE to "tar" and nicotine decreased 50% and 32%, respectively.

Camel Blue* and Marlboro Gold** cigarettes were evaluated in multiple studies between 2000 and 2013. MLE to "tar" and nicotine per cigarette remained relatively constant across these studies. Daily MLE to "tar" and nicotine declined slowly over time. Across the studies, a wide range of individual MLEs to "tar" and nicotine was observed that illustrates the considerable impact of individual smoking behavior on potential smoke exposure.

*In the 2005, 2007, and 2009 studies, Camel Lights were evaluated.
**In the 2006, and 2009 studies, Marlboro Lights were evaluated.

Introduction

R.J. Reynolds Tobacco Company (RJRT) has been actively engaged in understanding the mainstream smoke yields achieved by smokers from their usual brand of cigarette. Five studies were conducted over 8 years to investigate the mainstream smoke yields achieved by smokers, or mouth level exposure (MLE), from various brand styles of cigarettes in the U.S. A filter-analysis-based method was used to estimate smoker MLE to "tar" and nicotine in the five studies.[1] The MLE estimates represent the maximum potential exposure to "tar" and nicotine that a smoker experiences when smoking their cigarette. Changes in MLE over time were assessed for two brand styles which were included in multiple studies (Camel Blue and Marlboro Gold). Filter tip ventilation was measured for brand styles included in the MLE studies conducted during 2007 and 2013. For these two studies, the relationship between MLE and filter ventilation was examined by regression analysis.

Methods

- Each study enrolled healthy smokers ≥ 21 years of age.
- The subject's usual brand was one of the study specific brand styles.
- Subjects collected their smoked cigarette filters (butts) over a one-day period (~24 hours).
- Spent filters were analyzed for MLE by Labstat ULC and Arista Laboratories.
- The length of the cigarette butts was measured and a 10 mm segment cut from the mouth end.
- The 10 mm segments were extracted with methanol and analyzed for nicotine by capillary GC with FID and analyzed for nicotine free dry particulate matter (NFDPM or "tar") by a UV absorbance method.
- The resultant linear regressions from the calibration smoking (prime calibration curves) are used to estimate nicotine and "tar" yields on a per-cigarette basis for each smoker.
- Per day MLE values were calculated:

$MLE_{day} = MLE_{cig} \times (\#\ butts\ collected + \#\ butts\ reported\ as\ not\ collected)$

MLE_{day} is the per-day MLE amount of "tar" or nicotine
MLE_{cig} is the per-cigarette determination of MLE "tar" or nicotine
# of cigarette butts collected by the subject
butts reported as not collected as self-reported by the subject

Results (MLE per Cigarette Comparisons)

Figure 1: Camel Blue MLE "tar" and nicotine per cigarette

Figure 2: Marlboro Gold MLE "tar" and nicotine per cigarette

Results (MLE for Specific Brand Styles Across Time)

Figure 3: Camel Blue MLE "tar" and nicotine per day

Figure 4: Marlboro Gold MLE "tar" and nicotine per day

Results (MLE vs. Ventilation)

Figure 5: Relationship between mean MLE "tar" and nicotine per cigarette and ventilation for 39 brand styles measured in two studies

Figure 6: Relationship between mean MLE "tar" and nicotine per day and ventilation for 39 brand styles measured in two studies

Summary and Conclusions

- Increasing filter ventilation is associated with reduced exposure to "tar" on a per-cigarette and "tar" and nicotine on a per-day basis.
- Per-cigarette MLE "tar" and nicotine have not changed appreciably across time for Camel Blue and Marlboro Gold.
- Smoker's daily MLE exposure to "tar" and nicotine have decreased over the time period that the brand styles have been followed.
- Within a group of smokers using the same brand style, a wide range of MLEs are observed.
- MLE provides a simple tool for evaluating:
  - Impact of cigarette design parameters, such as ventilation, on consumer's potential exposure.
  - Changes in potential smoke exposure from a single brand-style across time.

References and Acknowledgements

[1] Nelson, P., Chen, P., Dixon, M. & Stelcher, T. (2011). A survey of mouth level exposure to cigarette smoke in the United States. Regulatory Toxicology and Pharmacology, 61, 525-536.

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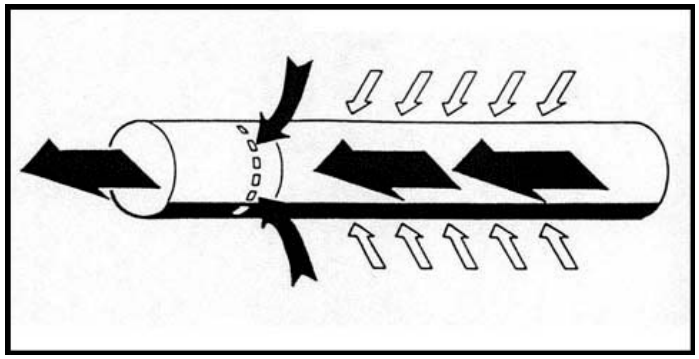
Background

- Cigarette filter ventilation allows air to be drawn into the mainstream smoke which dilutes the smoke

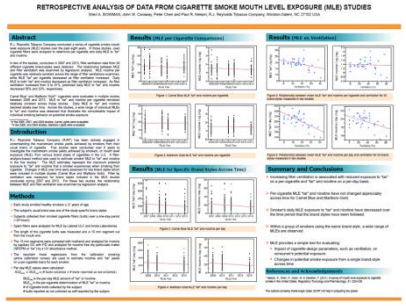


- This is a design tool which is important in controlling and reducing the yields of particulate and gas phase smoke components produced by cigarettes

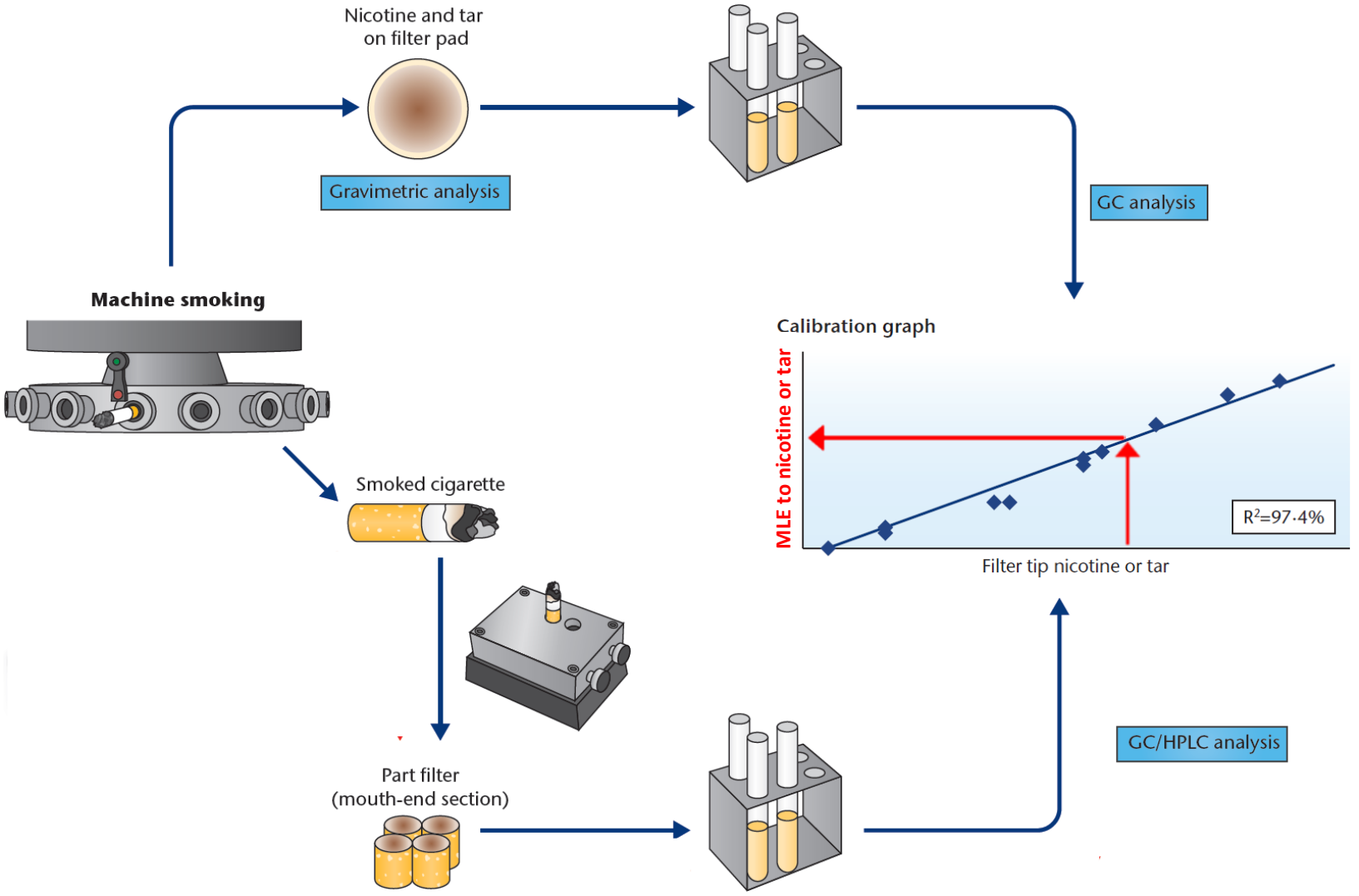
- Enables regulated ceilings for cigarette smoke components to be met
  - e.g., tar, nicotine and carbon monoxide

Background

- When cigarettes are machine-smoked using the Health Canada Intense (HCI) method, ventilation holes are fully blocked
- This gives rise to higher smoke yields than those produced under ISO conditions
- However, in typical use, few smokers block all ventilation holes
- Therefore, it is beneficial to study the effect of filter ventilation on human smoke exposure


RETROSPECTIVE ANALYSIS OF DATA FROM CIGARETTE SMOKE MOUTH LEVEL EXPOSURE (MLE) STUDIES

Methods – filter analysis to estimate mouth level exposure



Methods – field studies

- In previous BAT and RJRT studies we examined mouth level exposure (MLE) to tar and nicotine
- Current analysis used data collated from 11 studies across 9 countries
- Spent filters collected (24h or ≥15 filters) for MLE analysis
- Studies were performed between 2007 and 2013
- MLE to tar and nicotine data from 1,690 products and 6,400 subjects (>80,000 filters)
- Filter ventilation between 0% and 87%

Methods – field study locations

Methods – data analysis

- Per day MLE values were calculated:
- MLE_{cig} is the per-cigarette MLE for tar or nicotine
- MLE_{day} is the per-day MLE for tar or nicotine

RJReynolds

$$MLE_{day} = MLE_{cig} \times (\#\ butts\ collected + \#\ butts\ reported\ as\ not\ collected)$$

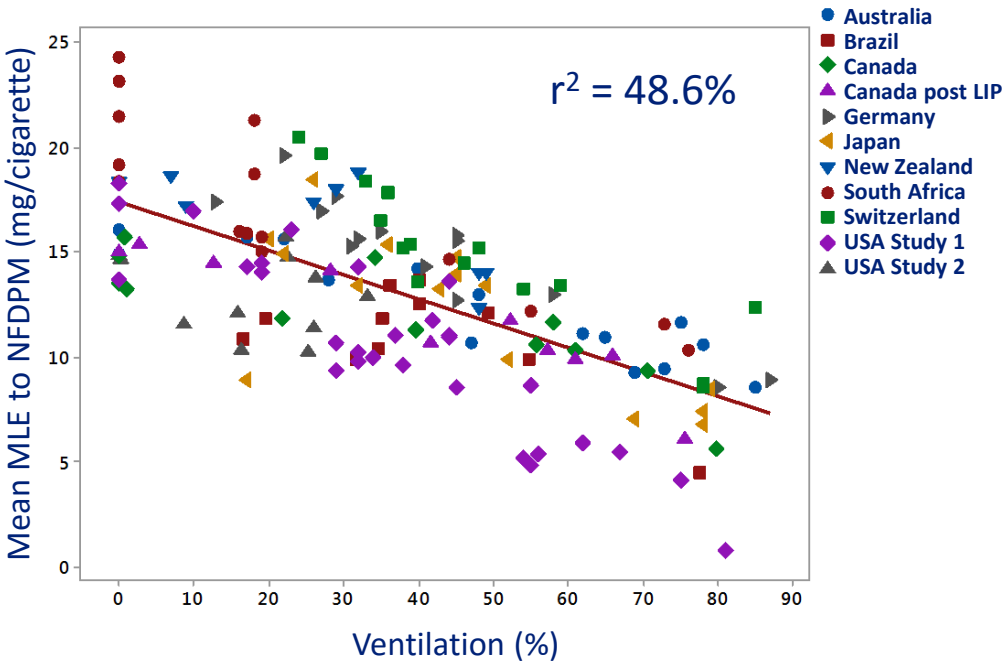
British American Tobacco

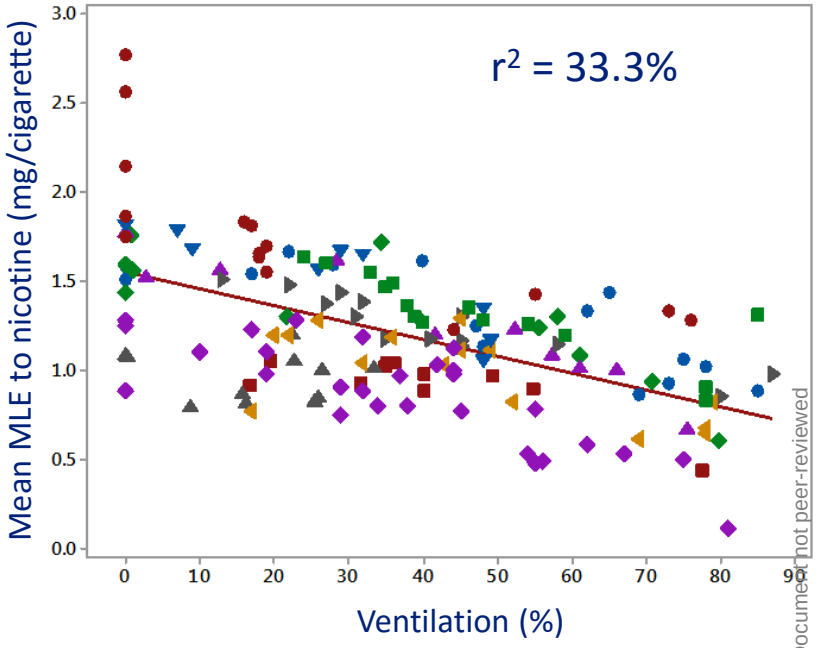
$$MLE_{day} = MLE_{cig} \times \#\ butts\ reported$$

- Plots of MLE_{day} and MLE_{cig} versus filter ventilation were fitted with linear regression lines
  - Individual countries as well as all countries combined

Results – combined data

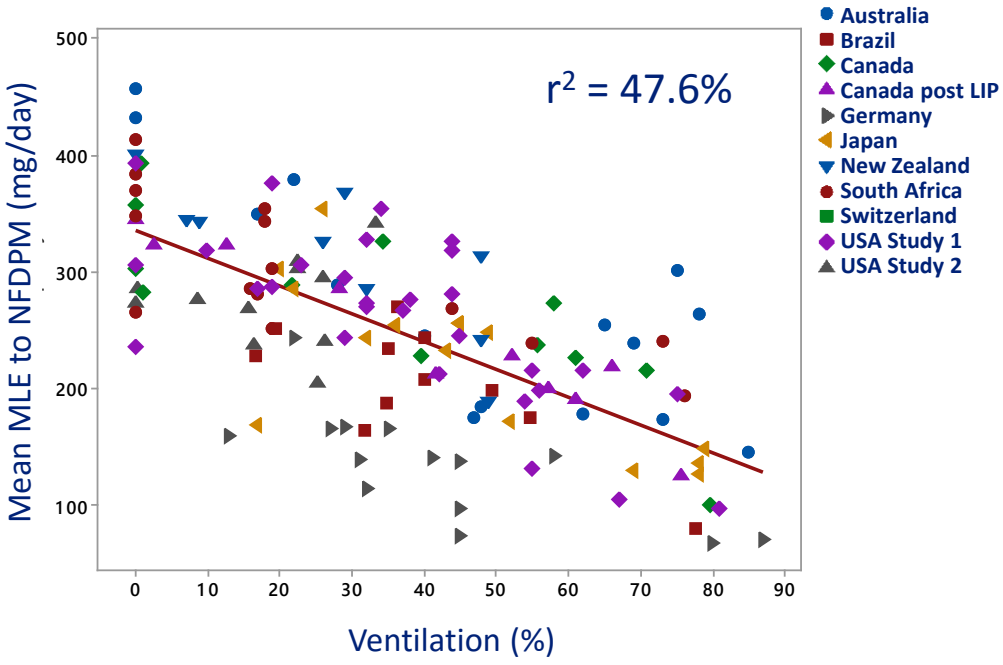
- Increasing filter ventilation from 0% to 87% was associated with a decrease in per cigarette MLE to tar and nicotine

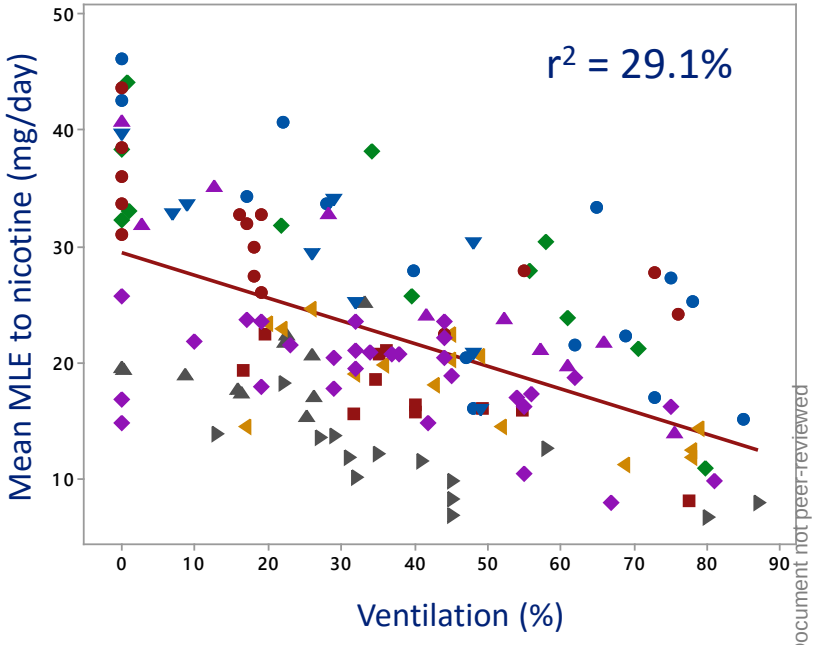




Results – combined data

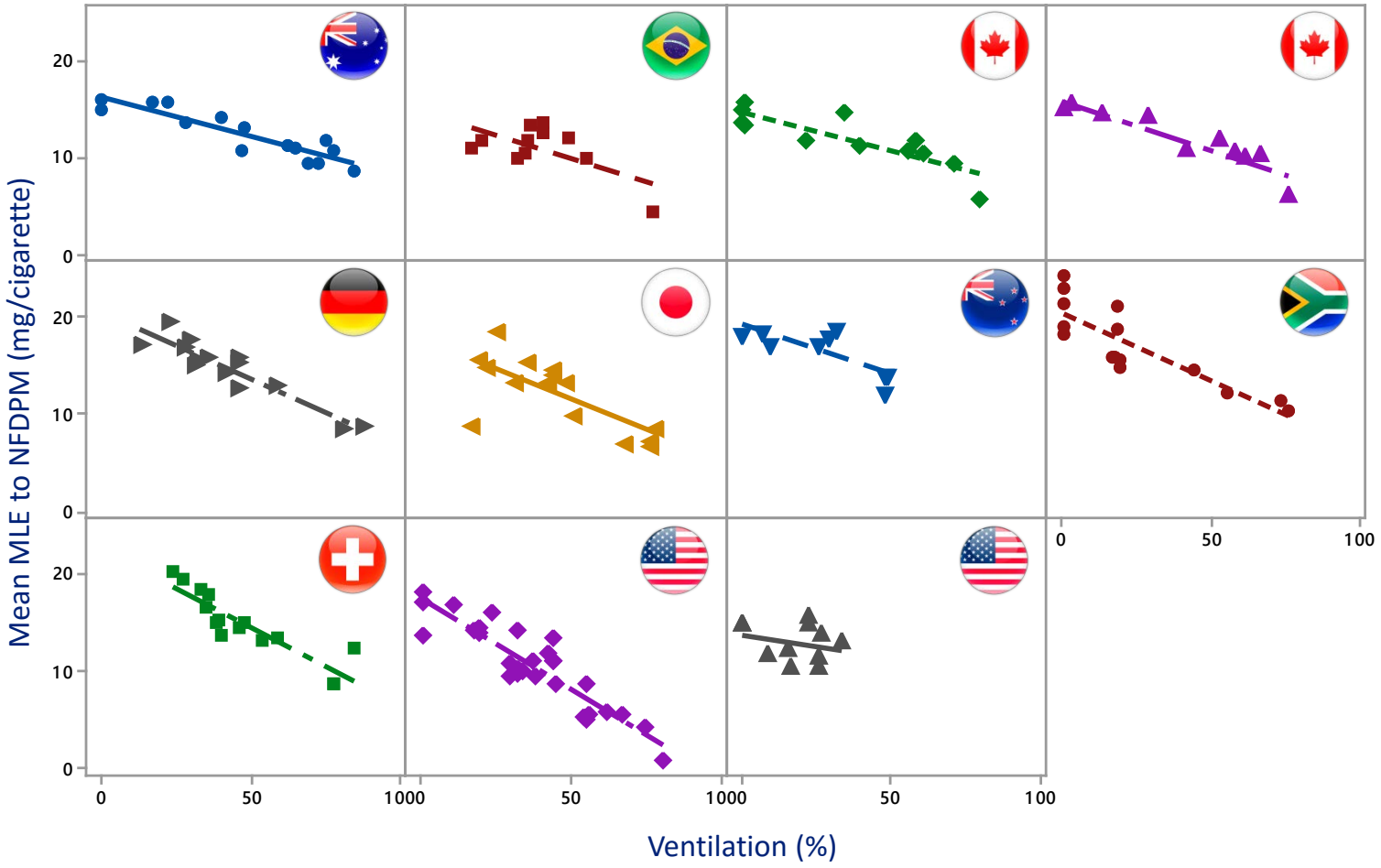
- Increasing filter ventilation from 0% to 87% was associated with a decrease in daily MLE to tar and nicotine





Results – individual countries

- Per cigarette MLE to tar and nicotine tended to decrease as filter ventilation increased



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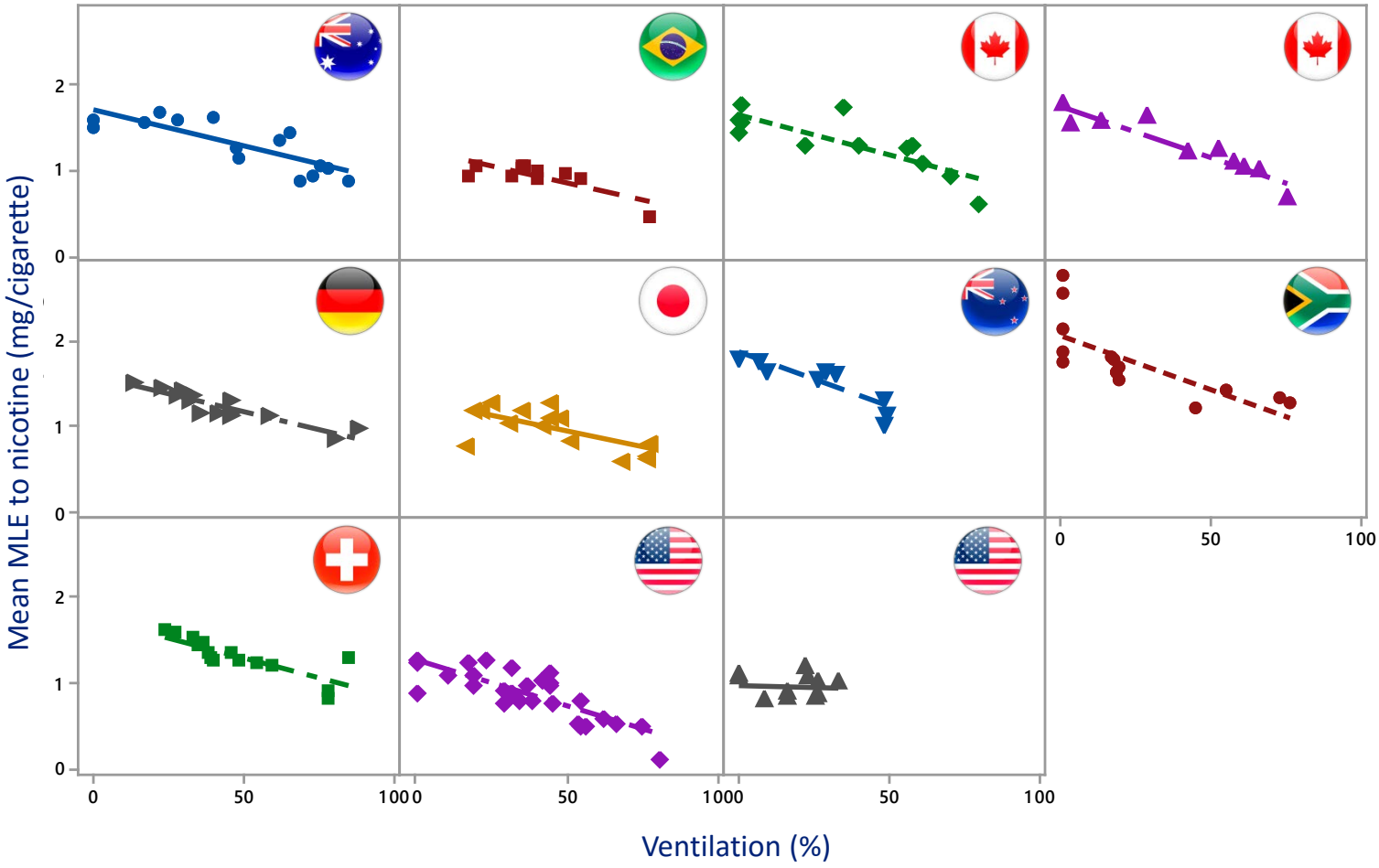

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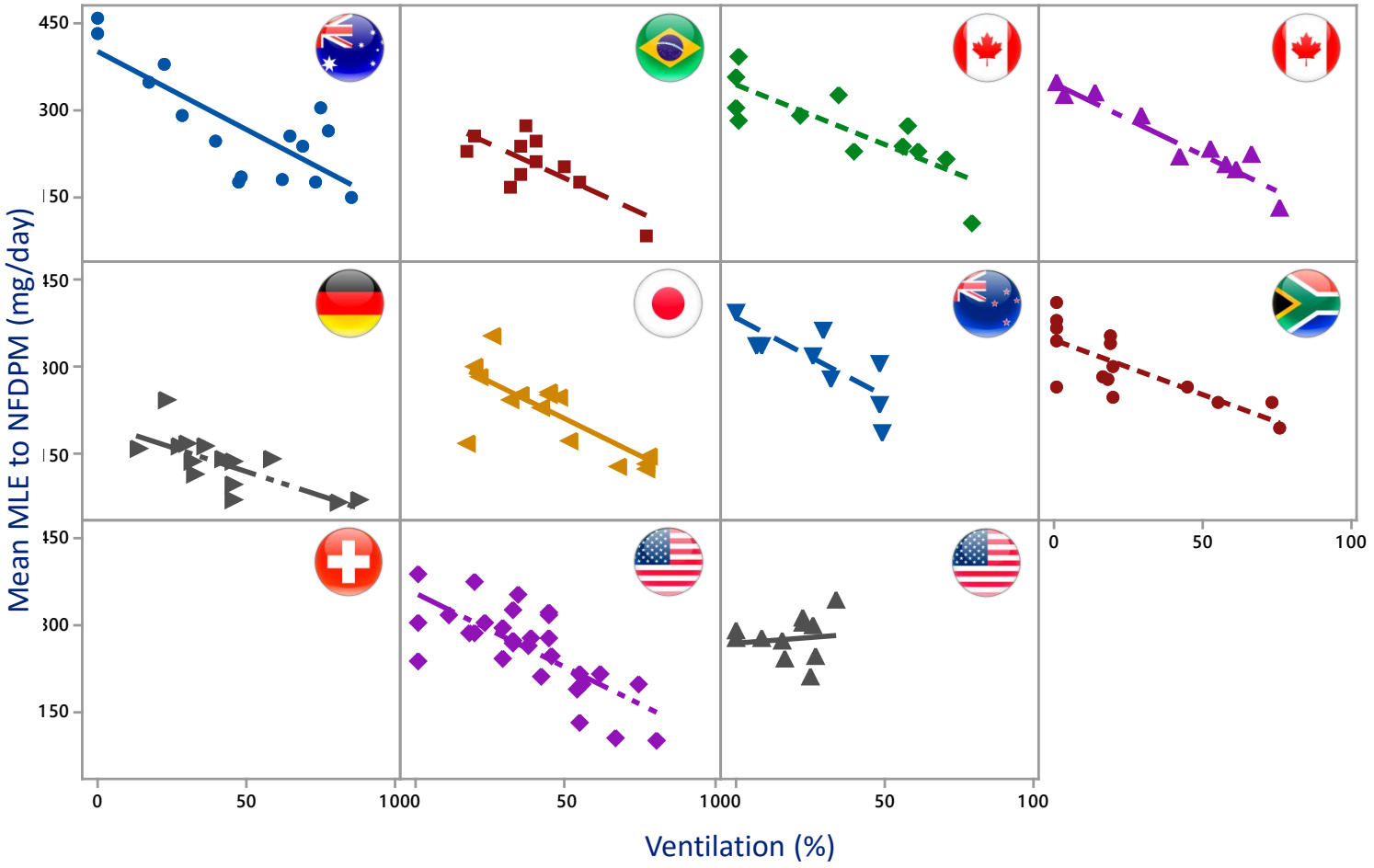

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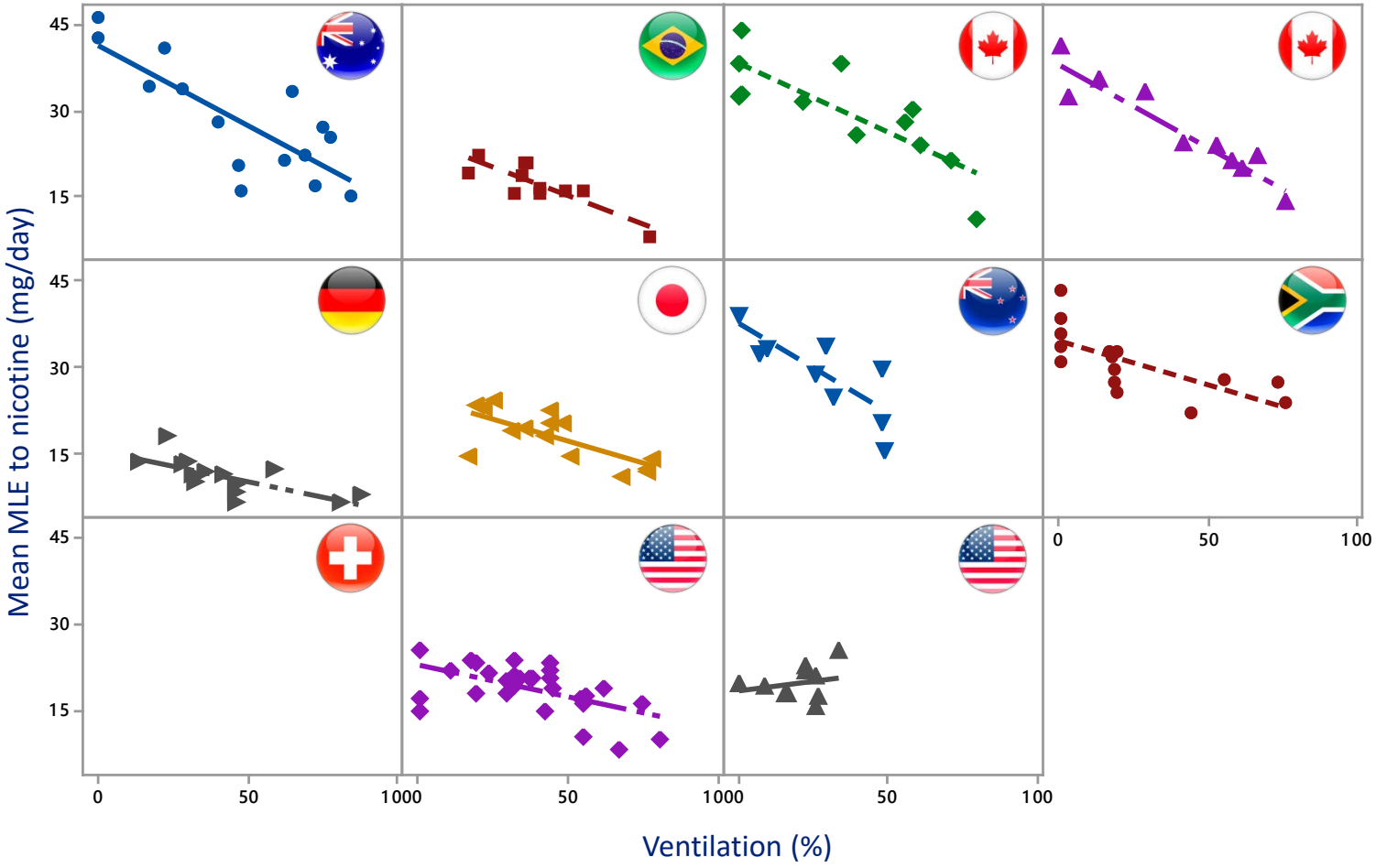
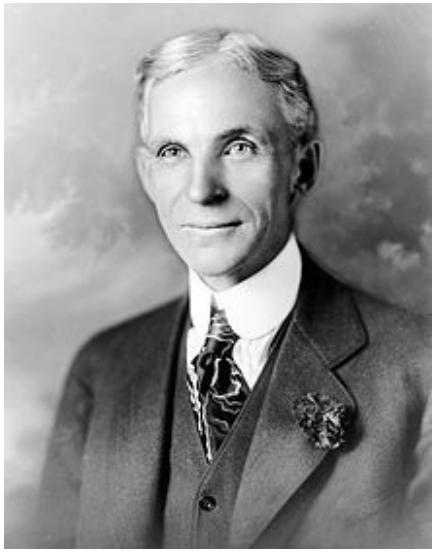


Summary and conclusions

- Cigarette filter ventilation was associated with a reduction in MLE to tar and nicotine when examined under subjects' natural smoking behaviour
- Data from second USA study likely reflect inclusion of a narrow range of ventilation levels
- Greater reductions observed at higher ventilation rates
- These data do not support the view that smokers fully compensate for cigarette ventilation; however, they do suggest that increasing cigarette ventilation tends to reduce exposure to nicotine and tar
- It is important to note that other confounding factors are present in ventilated cigarettes



Coming together is a beginning, staying together is progress, and working together is success.
Henry T. Ford

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