

Tobacco Use Harm Reduction, Elimination, and Escalation in a Large Military Cohort

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Cigarette smoking is the number 1 preventable cause of death and disability in the United States.^{1,2} Although a vast array of smoking cessation strategies exist,³ nearly 20% of the US population are current smokers.⁴ Impeding efforts for a tobacco-free society are the facts that nicotine is highly addictive⁵ and, at any given time, only about 20% of smokers are ready, willing, or able to make a serious attempt to stop smoking.⁶ Although research efforts are under way to evaluate the efficacy of approaches for smokers not ready or able to quit (e.g., motivational interviewing),⁷ no method has demonstrated success.

An alternative approach to providing treatment to smokers unable to quit is to “reduce the harm” associated with cigarette smoking.⁸ Proposed harm reduction strategies have included risk factor modification (e.g., dietary intake and physical activity) and chemoprevention strategies (e.g., antioxidants).⁹ However, the most controversial method of harm reduction is encouraging smokers to switch from cigarette smoking to other forms of tobacco, such as smokeless tobacco,^{10,11} a known human carcinogen.^{12,13}

Although switching from cigarettes to smokeless tobacco reduces risk related to heart disease and lung cancer,^{14,15} critics of this strategy suggest that harm reduction may be associated with unintended consequences. A recent review by Tomar et al. concluded that the effectiveness of smokeless tobacco as a smoking-cessation strategy remains unknown and that available evidence suggests that smokeless tobacco use may be a gateway to smoking initiation in the United States.¹⁶ Furthermore, promoting smokeless tobacco for harm reduction has the potential to increase harm by opening the door to dual use of cigarettes and ST, with the latter used in venues where smoking is prohibited; this could undermine cessation attempts.^{16,17} In the INTERHEART study, an international case-control study, dual use (i.e., concomitant use of cigarettes and smokeless tobacco) was associated

Objectives. We evaluated changing patterns of tobacco use following a period of forced tobacco abstinence in a US military cohort to determine rates of harm elimination (e.g., tobacco cessation), harm reduction (e.g., from smoking to smokeless tobacco use), and harm escalation (e.g., from smoking to dual use or from smokeless tobacco use to smoking or dual use).

Methods. Participants were 5225 Air Force airmen assigned to the health education control condition in a smoking cessation and prevention trial. Tobacco use was assessed by self-report at baseline and 12 months.

Results. Among 114 baseline smokers initiating smokeless tobacco use after basic military training, most demonstrated harm escalation (87%), which was 5.4 times more likely to occur than was harm reduction (e.g., smoking to smokeless tobacco use). Harm reduction was predicted, in part, by higher family income and belief that switching from cigarettes to smokeless tobacco is beneficial to health. Harm escalation predictors included younger age, alcohol use, longer smoking history, and risk-taking.

Conclusions. When considering a harm reduction strategy with smokeless tobacco, the tobacco control community should balance anticipated benefits of harm reduction with the risk of harm escalation and the potential for adversely affecting public health. (*Am J Public Health.* 2010;100:2487–2492. doi:10.2105/AJPH.2009.175091)

with higher odds for acute myocardial infarction than was cigarette smoking alone.¹⁸ Finally, it is important to point out that, although switching from cigarette smoking to smokeless tobacco is safer than smoking cigarettes, smokeless tobacco is still far from safe.^{12,13}

Proponents of harm reduction claim that for cigarette smokers who find complete smoking cessation an unobtainable goal, reducing harm through use of alternative nicotine sources with fewer health risks is better than continuing to smoke. These advocates often cite Sweden's promotion of the smokeless product “snus” as an example of effective harm reduction.¹⁹ Swedish snus use has been linked to a decrease in smoking prevalence and a net population health benefit.^{20,21} However, available data suggest that the Swedish and US populations behave differently.²² Specifically, both US male and female smokers have higher quit rates than in Sweden despite the higher rate of snus use in Sweden. Analysis of data in populations with high rates of tobacco use (both cigarettes and smokeless tobacco), such as the US military,²³

may provide additional information regarding the behavior of US tobacco users.

We explored tobacco use patterns in a large military cohort from basic military training to 12-month follow-up. During basic military training, all tobacco use is forbidden (a well-enforced prohibition) for a 6-week period; therefore, smokers and smokeless tobacco users undergo forced tobacco abstinence. We assessed the extent to which cigarette smokers in this population switched to smokeless tobacco (e.g., harm reduction) following the smoking ban during basic military training.^{12,13,24} We also explored the extent to which smokers increased their potential risk by switching to dual tobacco use (e.g., harm escalation).

METHODS

Our study is a secondary analysis from a large randomized controlled trial conducted in the US Air Force to determine the efficacy of a tobacco control program that combined forced tobacco abstinence with a tobacco

prevention intervention. Although the primary results for this trial have been reported elsewhere,²⁵ we provide a brief description here.

Description of Parent Study

The parent study²⁵ evaluated the effect of a brief tailored smoking control intervention delivered during basic military training on tobacco use among a population of military personnel ($n=33\,215$). Participants were randomized to either a tobacco use intervention group (smoking cessation, smokeless tobacco use cessation, or prevention, depending on tobacco use history) or a health education control condition. Results indicated that smokers who received the intervention were more likely to be abstinent than were control group participants at the 12-month follow-up. Similarly, smokeless tobacco users were statistically more likely than were controls to be abstinent at follow-up. The smoking prevention intervention had no impact on smoking initiation. The current study analyzed data from the 5225 participants who comprised the control group in the parent study.

Tobacco Ban

During basic military training, there is a total tobacco ban. The tobacco prohibition is well understood by military airmen ("airmen" is used in the Air Force regardless of gender or rank) before the start of basic military training, and the prohibition is strictly enforced. At the beginning of basic military training, airmen are searched and all tobacco products are confiscated. Tobacco products are considered "contraband" along with alcohol, drugs, weapons, and chewing gum. The airmen recruits are required to maintain a "money list" (i.e., a list of all serial numbers for all their money), which is checked regularly by basic military training instructors. Airmen are under constant supervision, and there are no tobacco products accessible even during those rare occasions when airmen are not supervised. An honor code is established early in basic training so that if a recruit breaks the rules, fellow airmen are duty bound to report the infraction. Finally, the punishment for tobacco use during basic military training is severe. In virtually all cases, the airman is "recycled" (forced to repeat some or all of basic training), a possible sanction that few airmen dare risk.

Study Population and Design

Participants were 5225 Air Force airmen assigned to the control condition in the larger investigation. We opted to exclude airmen assigned to the treatment and prevention arms to avoid potential confounding effects of the intervention. Airmen entered 6-week basic military training at Lackland Air Force Base in San Antonio, Texas, over a 12-month period in 1999 and 2000, and completed a follow-up survey 12 months later. Baseline measures were obtained during the second week in basic military training and follow-up surveys were mailed 12 months later, with follow-up telephone calls to airmen who had not returned the mailed questionnaire. The response rate for those airmen targeted for follow-up was 86.2%.²⁵ Female airmen made up 26% of both the original cohort and the sample for the current investigation.

Measures

The 68-question baseline survey covered several domains. Participants self-reported demographic information (age, gender, race/ethnicity, education, family income, and relationship status), history of tobacco and alcohol use, and lifestyle attitudes and behaviors. Because all tobacco use was prohibited during basic military training, cigarette and smokeless tobacco use immediately prior to basic military training were assessed with these questions: "What was your history of cigarette smoking just prior to basic military training?" and "What was your history of chewing tobacco or dip/snuff just prior to basic military training?" Response options were the following 7 categories: (1) never used, (2) used only on 1 or 2 occasions in the past, (3) used regularly (at least once per day) but quit in the past 6 months, (4) used regularly (at least once per day) but quit between 6 months and 1 year ago, (5) used regularly (at least once per day) but quit more than a year ago, (6) used but not every day, and (7) used every day.

Other tobacco-related variables of interest were age at first puff, age when daily smoking began, number of years smoking, pack-years, smoking status of parents and friends, attitude toward the basic military training tobacco ban, anticipated level of harm reduction one might expect from switching to smokeless tobacco, intention to maintain smoking abstinence after

basic military training, ownership of tobacco-sponsored items (e.g., shirt or cap), and attitude toward the tobacco industry.

Airmen reported their alcohol intake during the 30 days prior to basic military training with 1 of the following response options: "no intake at all," "drank once in that month," "drank 2–4 times that month," "drank at least once a week," "drank almost every day," or "drank every day." They reported the frequency of binge drinking during that period, defined as consuming 5 or more drinks on 1 occasion, as well as alcohol-related driving practices such as drinking and driving and riding with a drinking driver.

Definitions

At baseline, we defined smokers as daily or nondaily users of cigarettes (categories 6 and 7 for cigarettes) with no smokeless tobacco use. Smokeless tobacco users were defined as daily or nondaily users of smokeless tobacco (categories 6 and 7 for smokeless tobacco) with no cigarette smoking. Dual users were defined as daily or nondaily users of both cigarettes and smokeless tobacco (categories 6 and 7 for cigarettes and smokeless tobacco).

At 12-month follow-up, point-prevalence tobacco use was assessed by self-report. Airmen indicated whether they had smoked cigarettes or used smokeless tobacco within the past 7 days. Harm reduction was defined as cigarette smoking or dual use at baseline but no cigarette use in the past 7 days at follow-up. Harm escalation was defined as (1) smoking at baseline and both cigarette and smokeless tobacco use within the past 7 days or (2) smokeless tobacco use at baseline and smoking within the past 7 days. Harm elimination was defined as use of cigarettes, smokeless tobacco, or both at baseline and no cigarette or smokeless tobacco use in the past 7 days. Continuous smokers were baseline cigarette smokers who reported cigarette use but no smokeless tobacco use within the previous 7 days. Continuous smokeless tobacco users were baseline smokeless tobacco users who reported smokeless tobacco use but no cigarette use within the previous 7 days. Continuous dual users were baseline dual users who reported both smoking and smokeless tobacco use within the previous 7 days.

Statistical Analysis

Descriptive statistics and logistic regression analyses were generated with SAS version 9.1.3 (SAS Institute Inc, Cary, NC). The primary variables of interest in terms of defining tobacco use categories were (1) baseline and follow-up cigarette smoking status and (2) baseline and follow-up smokeless tobacco status. We also assessed baseline and follow-up “dual use” as the simultaneous use of both cigarettes and smokeless tobacco.

The first step in each analysis was to examine univariate logistic regression results for demographic, tobacco-related, and lifestyle variables. Variables with univariate results significant at the $P \leq .25$ level were retained for testing in the multivariate model. The second step was to fit the multivariate model with backward stepwise regression until the model contained only covariates significant at the $P < .05$ level.

RESULTS

Tobacco use status at baseline and follow-up is presented in Table 1. A total of 11.3% of never users at baseline were smokers at follow-up. An additional 0.7% of nonusers reported beginning smokeless tobacco use and 0.7% of nonusers reported initiating dual use of both cigarettes and smokeless tobacco at follow-up. Among baseline smokers and smokeless tobacco users, harm elimination was common, with 23.7% of smokers and 38.9% of smokeless tobacco users reporting nonuse (i.e., no tobacco in previous 7 days) at follow-up. Notably, the dual use pattern was not as stable over time as cigarette use or smokeless tobacco

use: 25.3% of dual users reported the same pattern of tobacco use at follow-up compared with 32.6% for smokeless tobacco users and 69.8% for smokers.

Harm reduction was uncommon, with only 15 of the 1751 baseline smokers (0.9%) giving up cigarettes and switching to smokeless tobacco use (Table 1). By contrast, 99 of 1751 baseline smokers (5.6%) demonstrated harm escalation by initiating smokeless tobacco use in addition to maintaining their smoking habit. The rate of harm escalation among smokeless tobacco users was pronounced, with 27 of the 193 baseline smokeless tobacco users (14.0%) switching to cigarettes and another 28 smokeless tobacco users (14.5%) becoming dual users. Of the 114 baseline cigarette smokers who initiated smokeless tobacco use, 99 (86.8%) demonstrated harm escalation by becoming dual users while only 15 (13.2%) demonstrated harm reduction by giving up cigarettes in favor of smokeless tobacco. Overall, baseline smokers who initiated smokeless tobacco use were 5.4 times more likely to demonstrate harm escalation than harm reduction. In addition, among the 118 baseline smokeless tobacco users who reported continued tobacco use at follow-up, 46.6% demonstrated harm escalation either by switching to cigarettes (22.9%, $n=27$) or becoming dual users (23.7%, $n=28$).

Predictors of Harm Reduction

We compared the group of airmen who demonstrated harm reduction (baseline smokers who switched to smokeless tobacco and baseline dual users who gave up smoking)

with the combined group of airmen who continued to be smokers or dual users from baseline to follow-up (Table 2). Harm reduction was more likely among smoking and dual-using airmen who reported an annual family income above \$70 000 (odds ratio [OR]=4.12; 95% confidence interval [CI]=1.47, 11.54; $P=.01$). Airmen who anticipated a moderate to large reduction in health risk by switching from cigarettes to smokeless tobacco were more than 3 times as likely to demonstrate harm reduction (OR=3.47; 95% CI=1.45, 8.31; $P=.01$). In addition, the odds of harm reduction were higher for smokers and dual users who reported that during the 12 months prior to basic military training they had owned a personal firearm (OR=8.58; 95% CI=4.49, 16.39; $P<.01$) and had driven aggressively or dangerously at least once a week (OR=2.84; 95% CI=1.10, 7.31; $P=.03$).

Predictors of Harm Escalation

We explored predictors of harm escalation by comparing smokers who became dual users with a reference group of smokers who remained smokers only. Predictors of harm escalation through dual use are shown in Table 3. Significant predictors of smokers becoming dual users were age and gender; harm escalation was less likely among older airmen (OR=0.81; 95% CI=0.71, 0.93; $P<.01$) and more likely among males (OR=6.12; 95% CI=2.44, 15.35; $P<.01$). Smoking history was significant, with greater number of pack-years associated with increased odds of harm escalation (OR=1.07; 95% CI=1.01, 1.13; $P=.02$), as was any alcohol consumption in the month prior to basic military training (OR=1.76; 95% CI=1.04, 2.97; $P=.04$). Finally, baseline smokers who owned a personal firearm in the 12 months prior to basic military training showed greater odds of becoming dual users (OR=1.72; 95% CI=1.09, 2.72; $P=.02$).

We compared baseline smokeless tobacco users who demonstrated harm escalation (i.e., became a dual user or switched to cigarettes) with the reference group of exclusive smokeless tobacco users. Risk-taking was a significant predictor for harm escalation. Smokeless tobacco users who agreed that illegal risk-taking was fun were more likely to escalate harm through smoking initiation (OR=5.19; 95% CI=1.05, 25.60; $P=.04$).

TABLE 1—Patterns of Tobacco Use at Baseline and 12-Month Follow-Up Among Military Personnel Exposed to 6-Week Period of Enforced Tobacco Abstinence: US Air Force, 1999–2001

Use at Baseline	Use at 12-Month Follow-Up			
	Nonuse, No. (%)	Cigarette Smoking Only, No. (%)	ST Use Only, No. (%)	Dual Use, No. (%)
Nonuse ($n=3032$)	2648 (87.3)	343 (11.3)	20 (0.7)	21 (0.7)
Cigarette smoking only ($n=1751$)	415 (23.7)	1222 (69.8)	15 (0.9)	99 (5.6)
ST use only ($n=193$)	75 (38.9)	27 (14.0)	63 (32.6)	28 (14.5)
Dual use ($n=249$)	51 (20.5)	105 (42.2)	30 (12.0)	63 (25.3)

Note. ST=smokeless tobacco. Baseline use could be daily or nondaily. Follow-up use was defined as use within the past 7 days. Total sample size was 5225.

TABLE 2—Predictors of Harm Reduction at 12-Month Follow-Up Among Participants Who at Baseline Were Smokers or Dual Users of Cigarettes and Smokeless Tobacco (ST): US Air Force, 1999–2001

Baseline Variable	Harm Reduction ^a	
	OR (95% CI)	P
Annual family income, \$		
≤25 000 (Ref)	1.00	
25 001–45 000	2.93 (0.97, 8.86)	.06
45 001–70 000	2.04 (0.66, 6.36)	.22
> 70 000	4.12 (1.47, 11.54)	.01
Perceived harm reduction of ST ^b		
No reduction (Ref)	1.00	
Small reduction	0.92 (0.34, 2.46)	.87
Moderate to large reduction	3.47 (1.45, 8.31)	.01
Bad driving in past y		
Not at all (Ref)	1.00	
< 1 time/mo	1.64 (0.79, 3.41)	.18
1 time/mo	1.83 (0.64, 5.22)	.26
1 time/wk or daily	2.84 (1.10, 7.31)	.03
Owned a personal firearm in past y		
No (Ref)	1.00	
Yes	8.58 (4.49, 16.39)	< .01

Note. CI = confidence interval; OR = odds ratio. Hosmer-Lemeshow goodness-of-fit-test: $\chi^2_8 = 3.82$; $P = .87$. "Harm reduction" describes a baseline cigarette smoker or dual user of cigarettes and ST who reported ST use but no cigarette use at 12-month follow-up. Total sample size was 1330.

^aAirmen who at baseline were smokers or dual users and who at 12-month follow-up were only ST users (harm reduction; $n = 45$) were compared with airmen who at baseline were smokers or dual users and who at 12-month follow-up continued to smoke or to be dual users ($n = 1285$).

^bPerception that ST causes less harm than does smoking.

DISCUSSION

Among all tobacco users in this study, harm elimination through the cessation of tobacco use following a protracted smoking ban was common, with 23.7% of baseline smokers and 38.9% of baseline smokeless tobacco users abstinent at follow-up. However, harm escalation occurred more frequently than did harm reduction. Overall, tobacco users who began using smokeless tobacco were more than 5 times more likely to demonstrate harm escalation than harm reduction. Harm reduction was more likely among baseline smokers and dual users who had higher family incomes and who believed that switching from cigarettes to smokeless tobacco provides a health benefit. Harm escalation was more prevalent among risk-taking younger men with a longer smoking history and any alcohol intake just prior to basic military training.

Consistent with the findings of other studies of this type, harm elimination following long bouts of forced abstinence was common in our study.^{19,20} Our data are very similar to those from an analysis of the 2002 and 2003 Tobacco Use Supplement to the Current Population Survey (TUS-CPS).²² In both our study and the TUS-CPS, (1) quitting rates were lower for cigarette smoking than for smokeless tobacco use at the 1-year follow-up, (2) exclusive cigarette use was a more stable pattern of tobacco use than were smokeless tobacco use or dual use, (3) switching from one type of tobacco use to another was infrequent and was more likely to be from smokeless tobacco to cigarettes than from cigarettes to smokeless tobacco, and (4) harm reduction (i.e., from smoking or dual use to smokeless tobacco only) was much less common than was harm escalation (i.e., from smoking or smokeless tobacco use to dual use). Our finding that dual users were the most likely of the groups

to switch tobacco use patterns and the least likely to report nonuse at follow-up was also consistent with previous studies.^{26,27} Considered together, these data would suggest that in the United States, harm escalation may lower the probability of becoming tobacco abstinent if smokers become dual users. This escalation is a possible unintended consequence of promoting smokeless tobacco as a harm reduction strategy for smokers.

Our observation that harm escalation (i.e., from smoking to dual use) was more likely among men than among women is not unexpected. This observation is consistent with the low prevalence of overall smokeless tobacco use among women,²⁹ which is likely related to cultural norms in the United States pertaining to smokeless tobacco use. Even in Sweden, where smokeless tobacco use is prevalent (20% of adult males use smokeless tobacco)³⁰ and holds unique historical and cultural significance, the prevalence of smokeless tobacco use among women is low.²⁰ In a study assessing tobacco quitting or switching in the TUS-CPS, smokeless tobacco use among women was low and no women demonstrated harm reduction.²² Our findings and those of other investigators suggest that a harm reduction strategy using smokeless tobacco would have little or no impact on women in the United States.

A public health policy promoting a harm reduction approach with smokeless tobacco may require a more complete understanding of the demographics, behaviors, and knowledge of individuals who may be vulnerable to harm escalation. We observed that harm escalation was more prevalent among risk-taking younger men who had longer smoking histories and had reported recent alcohol intake just prior to basic military training. In a cross-sectional analysis of the Working Well Trial study population, dual users (of cigarettes and smokeless tobacco) were more likely to be younger, unmarried, and White and to have lower levels of education than were cigarette smokers, but were similar in age and race/ethnicity to smokeless tobacco users.²⁷ Dual users in the Working Well Trial population also drank more alcohol and were more likely than were cigarette smokers or smokeless tobacco users to live with a smoker. Importantly, dual users were less likely to become tobacco abstinent than were smokers or smokeless tobacco

TABLE 3—Predictors of Harm Escalation at 12-Month Follow-Up Among Participants Who at Baseline Were Smokers: US Air Force, 1999–2001

Baseline Variable	Harm Escalation ^a	
	OR (95% CI)	P
Older age	0.81 (0.71, 0.93)	<.01
Gender		
Female (Ref)	1.00	
Male	6.12 (2.44, 15.35)	<.01
Pack-years	1.07 (1.01, 1.13)	.02
Alcohol consumption 30 d prior to BMT		
No (Ref)	1.00	
Yes	1.76 (1.04, 2.97)	.04
Owned a personal firearm in past y		
No (Ref)	1.00	
Yes	1.72 (1.09, 2.72)	.02

Note. BMT=basic military training; CI=confidence interval; OR=odds ratio. Hosmer–Lemeshow goodness-of-fit-test: $\chi^2_8=5.51$; $P=.70$. “Harm escalation” describes a baseline cigarette smoker who reported dual use of cigarettes and smokeless tobacco at 12-month follow-up. Total sample size was 1321.

^aAirmen who at baseline were smokers and who at 12-month follow-up were dual users of cigarettes and smokeless tobacco (harm escalation; $n=99$) were compared with airmen who at baseline were smokers and who at 12-month follow-up were still smokers but not users of smokeless tobacco ($n=1222$).

users, and whereas traditional indicators of tobacco dependence (e.g., smokeless tobacco use per day or cigarettes per day) predicted abstinence from smokeless tobacco and cigarettes, those indicators did not predict abstinence from dual use. Random-digit-dialing surveys in Australia, Canada, the United Kingdom, and the United States suggest that smokers in the United States are the least likely to believe that smokeless tobacco is less harmful than are cigarettes.³⁰ Although this belief may indeed reflect a “major failing of public education about the relative harms of tobacco products,”^{30(p1039)} we submit that any public health campaign must disclose any potential harm escalation associated with dual use.¹⁸ We did observe that airmen who believed that smokeless tobacco use was less harmful than cigarettes were more likely to demonstrate harm reduction. In the current environment in the United States, however, our data and that of other investigators suggest that harm escalation is the more probable use pattern among cigarette smokers.

Our study is strengthened by the prospective design, the large sample size, the young age, the ability to observe tobacco reinitiation after a period of forced abstinence in basic military training, and the high representation of

minorities and individuals with low incomes. Our study is limited because it uses a military population with only 1 year of follow-up. Furthermore, because our study involved forced tobacco abstinence, our findings may not apply to a population of smokers presenting for treatment. It is also important to note that our study participants were military personnel who tended to be predominantly young, male, from lower-income families, and predominantly racial/ethnic minorities. Whether our findings generalize to a civilian population is unknown and should be the focus of additional research. However, our study results were consistent with results of other studies in the literature that have used civilian samples.

Despite study limitations, we provide important additional information to the debate over a harm reduction approach to smoking that incorporates the use of smokeless tobacco. In our control sample, a significant number of smokers were able to quit, but these smokers were also more likely to demonstrate harm escalation than harm reduction. Future studies should also evaluate the relative health risks of harm escalation versus reduction. Before embarking on a public health education program promoting smokeless tobacco use for

smokers, the tobacco control community needs to carefully weigh the likelihood and benefits of switching cigarette smokers to exclusive smokeless tobacco use against the risk of having smokers become dual users and thereby increasing rather than decreasing the adverse health consequences of tobacco use. ■

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Note. Expressed views are those of the authors and do not represent the official position of the US Air Force Basic Military Training, the Department of Defense, the Department of Veterans Affairs, or the US Government.

Contributors

R. C. Klesges conceptualized the project and led the writing of the article. D. Sherrill-Mittleman conducted all analyses and contributed to the writing of the article. J. O. Ebbert contributed to the writing of the article and made substantive editorial contributions. G. W. Talcott and M. DeBon were responsible for the successful execution of the entire project. All authors reviewed drafts and contributed to the final revision.

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Human Participant Protection

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