

The Effect of Product Safety Regulation on Safety Precautions

W. Kip Viscusi^{1,2} and Gerald O. Cavallo¹

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This paper explores the means by which lighter safety regulations alter the precautionary behavior of 200 subjects in a field test of cigarette lighters with a child-resistant feature. The new lighter design leads respondents to believe the lighters are safer, but there is no clear-cut evidence that the effect on perceived risk levels is excessive. Using the estimated relationship between cigarette lighter risk perceptions and a variety of measures of precautions, this paper provides explicit estimates of the effect of regulations on precautionary behavior and on lighter safety. On balance, the child-resistant feature will reduce fire-related injuries by much more than any diminished precaution taking.

KEY WORDS: Risk perceptions; precautionary behavior; safety devices; risk homeostasis.

1. INTRODUCTION

Recent consumer product safety regulations have mandated that cigarette lighters have a child safety mechanism. Since lighter safety and children's use of lighters are closely linked to household fire risks, these regulations offer the potential for safety gains. However, their ultimate effect depends not only on the design characteristics but also on whether the presence of the child-resistant device leads to more lax handling of lighters and greater access to children. This paper reports on a field test involving 200 child-resistant lighters, in which we examine the character of the behavioral response to the new lighter designs.

Concern with safety precautions as well as safety designs is not a unique concern for cigarette lighters. There is a well-established link between workers' precautionary behavior and job safety.³ Similarly, continued concern with drunken driving highlights the ongoing importance of the driver's role in highway safety.

Government safety regulations may influence precautionary behavior, thus affecting the ultimate safety impact. In much the same manner as one would exercise greater care in driving an automobile on icy streets rather than on dry streets, drivers will have less of an incentive to take care if technological improvements in safety reduce the safety-related productivity of exercising care. If people overassess the efficacy of safety regulations, they may be lulled into a false sense of security, leading to a further decrease in care.⁴

Several empirical approaches to the effect of safety devices on precautions can be distinguished. The first variant is that those affected by a safety regulation may rationally reduce their safety precautions since taking precautions yields fewer benefits.⁵ For example, drivers may exercise less care or drive faster once seat belts or air bags become available, but the magnitude of this influence remains controversial.⁶ Evidence on diminished

¹ Department of Economics, Duke University, Durham, North Carolina 27708.

² To whom correspondence should be addressed.

³ See Ref. 16, pp. 26–27, for a review of this evidence.

⁴ This formulation was developed and tested in Refs. 17 and 19.

⁵ These results hold whether the mechanism of influence of the safety regulation is through decreasing the probability of an accident or decreasing the size of the loss for any given accident. See Refs. 12, 17, and 20.

⁶ See, for example, Refs. 3, 6, and 17.

precautions in response to safety cap regulations suggests that parents became increasingly prone to leaving medicines and other products accessible to children, thus diminishing the efficacy of these safety cap devices.⁷

A second variant of the effect on precautions is that individuals may become lax if they overassess the efficacy of the safety device. Under this hypothesis, termed the "lulling effect," consumers may overestimate the improvement in safety that will occur. Many leading government officials, for example, indicated that these devices made products "childproof," possibly reducing potential precautions more than would be dictated by the actual efficacy of the caps.⁸

A third economic concern arises from spillover effects on related products.⁹ Changes in the safety of one product may lead individuals to modify an entire class of activities, with ramifications for multiple products. For example, if households adopt a common storage policy for all medicines, introducing safety caps for some medicines may lead all medicines to be stored in a less safe place, even those without safety caps.

Models other than those devised by economists can explain diminished precautions in response to safety standards. These behavioral responses are also consistent with risk homeostasis theory, under which individuals have a target risk level.¹⁰ This theory, which was developed largely to address traffic safety accidents, suggests that individuals anchor their behavior on a target risk level. Safety standards reduce risk levels below the target, making diminished precautions to return closer to the target desirable.¹¹

The case study explored in this paper pertains to fire risks to children from cigarette lighters. In particular, the focus is on the influence of a lighter with child-resistant features on risk beliefs and precautions. This analysis utilizes an original database developed by the authors as part of premarket testing of the introduction of lighters with these mechanisms.¹² These data provide the most detailed assessment to date of the mechanisms driving the behavioral response to risk regulations.

⁷ See Refs. 17 and 19 for supporting theory and empirical evidence.

⁸ See Refs. 17–19.

⁹ See Refs. 17–19.

¹⁰ For advocacy of this approach, see Refs. 24 and 25, and for a critique, see Ref. 14.

¹¹ Although the risk homeostasis outcome is not the result of a conscious maximizing model, one should not necessarily rule out this approach or some other nonoptimizing target risk model on this basis. A substantial body of literature has documented a variety of forms of economic irrationality for risk-taking behavior.

¹² As of May 1993, the U.S. Consumer Product Safety Commission was still developing final regulatory guidelines for these lighters.

2. THE SAMPLE AND EXPERIMENTAL DESIGN

In the early 1990s, the Consumer Product Safety Commission (CPSC) developed a safety standard for child-resistant features for cigarette lighters, where the field testing supporting this policy was undertaken by the major lighter manufacturers. This paper utilizes data from one such test using an in-house placement and a protocol developed by the authors, but which substantially mirrored the test protocol eventually adopted by the CPSC. The child-resistant feature consisted of a safety mechanism on the lighter. Instead of rotating a spark wheel and depressing a lever to ignite the lighter, the user first had to disengage the safety mechanism. This mechanism would reset after each use so that it would need to be disengaged again for successive product trials. If the user did not disengage the latch, even substantial pressure on the lever would not be sufficient to activate the lighter.

A sample of 200 households participated in an in-house placement of the test lighter in 1990. An effort was made to achieve some geographical and demographic diversity. As indicated in the summary of sample characteristics in Table I, 44% of the sample was from the New York metropolitan area, and the remainder was roughly evenly divided between Memphis, Tennessee, and Chicago, Illinois. This sample is not a random national sample, but the sample of current lighter users is also not a random segment of the population. The statistical analysis controls for demographic characteristics, making projections to other population groups possible.

Because of the study's focus on the use of cigarette lighters, the sample was restricted to cigarette smokers who regularly use a lighter. A second screen for participation in the study is that the household had to include children in the primary age range at risk, children 40–60 months. The survey was structured in a manner so that roughly 50% of the participants would be in the age range 40–51 months, and the remainder would be in the age range 52–60 months. Because children's development of small motor coordination and dexterity differs across sexes, the sample was evenly divided between male and female children. The sample screens consequently make this a nonrandom sample of the population, but a good reflection of the population at risk from fire-related hazards of cigarette lighters.¹³

¹³ Overall, 42% of the sample had some college education, compared with 40% of the U.S. population age 25 and over. See Ref. 15, p. 144. The restriction to households with smokers substantially affects the demographic mix of the sample. The sample included more blue-collar workers than white-collar workers and a roughly average educational level.

Table I. Sample Characteristics^a

Variable label	Definition	Mean (SD)
Demographic variables		
FATHER	Responding parent is father, 0–1 dummy variable (d.v.)	0.26 (0.44)
COLLEGE	Respondent has college or more education, 0–1 d.v.	0.42 (0.49)
MALE-KID	Child is male, 0–1 d.v.	0.49 (0.50)
YOUNG-KID	Child is in younger age group, yrs d.v.	0.58 (0.49)
BLACK	Respondent is black d.v.	0.17 (0.37)
HISPANIC	Respondent is Hispanic d.v.	0.06 (0.24)
INCOME	Reported household income, in thousands \$	30.36 (17.99)
INCOME>60K	Reported household income above \$60,000 d.v.	0.13 (0.33)
INCOME-MISSING	No response to income question, d.v.	0.02 (0.12)
SAFETY-CAPS	Respondent strongly or moderately agrees that “I always buy medicine with safety caps”	0.84 (0.37)
NO-SEAT-BELTS	Respondent strongly or moderately agrees that “There are times when my child rides without a seat belt”	0.55 (0.50)
NYMETRO	Residence in NY metropolitan area d.v.	0.44 (0.50)
CHICAGO	Residence in Chicago metropolitan area d.v.	0.27 (0.45)
MEMPHIS	Residence in Memphis metropolitan area d.v.	0.29 (0.46)
Lighter risk perceptions		
DANGER	Danger rating of conventional lighter on 10-point scale from not at all dangerous (1) to extremely dangerous (10)	8.24 (2.73)
CONCERN	Concern rating of conventional lighter on 10-point scale from not at all concerned (1) to extremely concerned (10)	9.30 (1.62)
DANGER-TEST	Danger rating of test lighter on 10-point scale from not at all (1) to extremely (10)	5.10 (2.74)
CONCERN-TEST	Concern rating of test lighter on 10-point scale from not at all concerned (1) to extremely concerned (10)	5.85 (3.04)
Safety precautions		
PRECAUTION	Took precautions with test lighter, d.v.	0.88 (0.33)
ACCESS	Left test lighter where child could reach d.v.	0.07 (0.26)
LESS-CAREFUL	Parents will be less careful with test lighter d.v.	0.48 (0.50)
LESS-TEACHING	Agree or only moderately disagree that parents will spend less time teaching about fire hazards (d.v.=1) versus strongly disagree (d.v.=0)	0.31 (0.46)

^a Sample size: 200.

Table I. *Continued*

Variable label	Definition	Mean (SD)
Lighter placement		
ON-PERSON	Respondent kept lighter on person d.v.	0.43 (0.50)
LIVING ROOM/KITCHEN	Respondent kept lighter in living room/kitchen d.v.	0.75 (0.43)
BEDROOM/BATHROOM	Respondent kept lighter in bedroom or bathroom d.v.	0.25 (0.43)
OTHER-ROOM	Respondent kept lighter in another room d.v., e.g., garage	0.05 (0.22)
General perception/precaution variables		
PEACE-OF-MIND	Test lighter provides more peace of mind d.v.	0.88 (0.33)
REDUCE-FIRES	Strongly agree that test lighter will reduce fires/injuries d.v.	0.47 (0.50)

The first set of variables in Table I consists of the usual demographic variables as well as information with regard to two proxies for risk attitudes—the extent to which the household always purchased medicines with safety caps (SAFETY-CAPS) and the degree to which the respondent permits his or her child to ride in cars without a seat belt (NO-SEAT-BELTS). Since the study focuses on the smoking population, this population may be more willing to bear risks than the general population.¹⁴ Thus, there should be less variation in the safety cap and seat belt use responses than there would be if the sample included a broader cross section of society.

The second set of variables in Table I pertains to risk beliefs. The survey utilized two risk perception scales to assess the prior risk assessment for conventional lighters and the posterior risk assessment for the lighter with the child-resistant feature. The survey structure was longitudinal in design, as it tracked the individual household both before and after the in-house placement of the lighter. Both the preinterview and the interview after the in-house placement segment of the study were completed included questions regarding safety precautions and lighter placement. These various measures are summarized at the end of Table I. In some cases, the variable pertains directly to precautions, whereas in other cases it bears on precautions less directly.

Extensive focus group interviews undertaken by the authors identified the factors most strongly related to precautionary behavior and to develop question wording. The survey included variables that the focus groups suggested were strongly related to their precautionary ac-

tions, such as whether the test lighter provides more “peace of mind.”

At the conclusion of the study, the children participating in the study were instructed in the importance of never playing with lighters. Special care was undertaken throughout the study to conform with the ethical concerns in similar government test protocols, such as for safety caps.

3. SHIFTS IN RISK PERCEPTIONS

The main mechanism generating decreased precautions is that the child-resistant feature makes users think lighters are safer. This diminished perceived risk reduces the safety benefits from taking precautions, making precaution-taking less likely.

3.1 Measures of Risk Perceptions

The first approach to assessing the effect on beliefs was to utilize a DANGER scale in which the respondents rated the danger of the test lighter on a 10-point scale ranging from not at all risky (score of 1) to extremely risky (score of 10). The second variant of the risk rating scale was also a 10-point scale, where in this case respondents indicated the degree of their CONCERN with respect to the conventional lighter on a scale ranging from not at all concerned (score of 1) to extremely concerned (score of 10). Use of two measures will indicate the robustness of the results to different wordings of the risk perception question. The use of

¹⁴ See Refs. 7, 11, and 21, which document the relationship of risk taking across different classes of activities.

Table II. Risk Assessments by Lighter Type

	Mean (SE)	
	Conventional lighter	Test lighter
DANGER	8.25 (0.15)	5.10 (0.19)
CONCERN	9.30 (0.11)	5.85 (0.22)

DANGER scales has substantial precedence in the literature.¹⁵

3.2. Estimates of Risk Perceptions

Table II summarizes the assessed risks for each lighter type. The lighter with the child-resistant feature is designated the "test" lighter. The overall DANGER assessment decreases from 8.25 for the conventional lighter to 5.10 for the test lighter. Similarly, the overall CONCERN assessment drops from 9.30 for the conventional lighter to 5.85 for the test lighter. A difference of means test indicates that these declines in the assessed DANGER and CONCERN levels are statistically significant.¹⁶ The child-resistant feature lowers consumers' risk perceptions substantially. This decrease establishes the main perceptual prerequisite for a decrease in precautions.

A related concern is whether consumers overestimate the safety improvement. One caveat is that our results are based on a field test in which respondents were told that they would be using a lighter with a child-resistant feature, but this mechanism was not called "childproof." How the lighter is presented to the public and the extent to which misperceptions are fostered by an incorrect characterization of the product may influence risk beliefs.

¹⁵ In particular, three previous studies indicate that giving respondents such a quantitative metric will generate assessments of risk that are consistent with objective measures of the hazard. In Ref. 23, the authors used a continuous scale to assess job risks, where the same danger wording used in this survey was indicated. Respondents marked the point on the line that best corresponded to their risk beliefs. The second labor market study that modified the danger scale to be in terms of a discrete series of intervals that more closely parallel those used in this lighter study was Ref. 11. Finally, a more elaborate risk scale based on a similar notion has also been employed in Ref. 8, which analyzed labor market fatality risks. All three of these studies generated estimated wage premiums for risk comparable to those generated using published risk statistics.

¹⁶ Child-resistant lighter test run by Gerald Cavallo, July 1990.

To assess the accuracy of the risk perception shift, one must first establish a benchmark for the efficacy of the child-resistant feature. In a separate series of tests, we explored the degree to which children could operate the conventional lighter and the test lighter.¹⁷ The child was given the lighter for a 5-min period. If the child could not operate the lighter, the survey administrator showed the child how to use the lighter. Participants were then given a second 5-min period to attempt to operate the lighter. The survey administrator ascertained what percentage was able to obtain a light using the lighter during these trial periods. For the conventional lighter, 62% of the children were unable to operate the lighter after two 5-min test periods, the first without a demonstration and the second following a demonstration. Viewed somewhat differently, the percentage of children able to obtain a light was 38. For the test lighter, 95% of the children were unable to obtain a flame. Thus, the percentage of children able to obtain a light for the lighter with the child-resistant feature is 5.

The fraction of the children who could successfully operate the lighter was 87% lower for the test lighter (or 33 percentage points in absolute terms) than for the conventional lighter. The DANGER risk assessments for the test lighter were only 38% lower for the test lighter than the conventional lighter, and the CONCERN assessments for the test lighter were only 37% lower for the test lighter than for the conventional lighter. These results suggest that the proportional decrease in the assessed risk of the test lighter is less than the actual risk reduction. There is consequently no evidence based on the proportional risk belief changes that respondents are excessively optimistic.¹⁸

Another perspective on the potential for risk underestimation is to examine outliers. Were some respondents lulled into an extreme but unwarranted sense of safety, with a DANGER or CONCERN score in the lowest risk level (a score of 1)? For the conventional lighter, no respondents gave a score of 1 using either of the two risk scales. However, after the introduction of the child-resistant feature, 18 respondents assessed the risk of the test lighter as being 1, and 16 respondents assessed the

¹⁷ As of 1993, the CPSC had not finalized a protocol for cigarette lighter safety testing. This part of the study used an electronic lighter device so that no flame was actually emitted. In addition, participants underwent extensive debriefing on fire safety and the importance of not playing with lighters.

¹⁸ The absolute magnitude of the decrease in risk perceptions may not be accurate. These results are not, however, conclusive with respect to biases in the level of risk perceptions. For example, if the initial risk assessments were too high(low), then the assessed risk for the test lighter might be too high(low) as well.

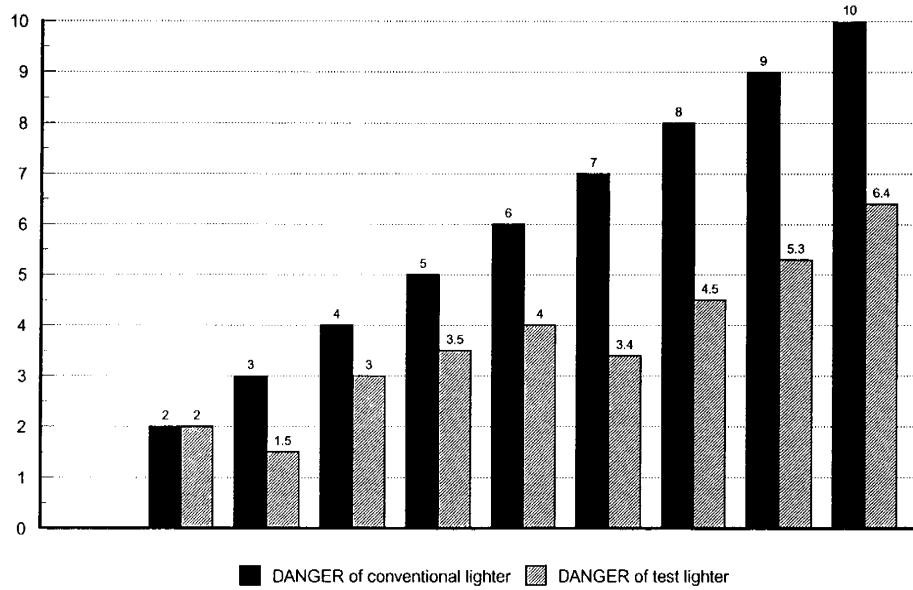


Fig. 1-A. Relation of DANGER Assessments for Conventional Lighter and Test Lighter.

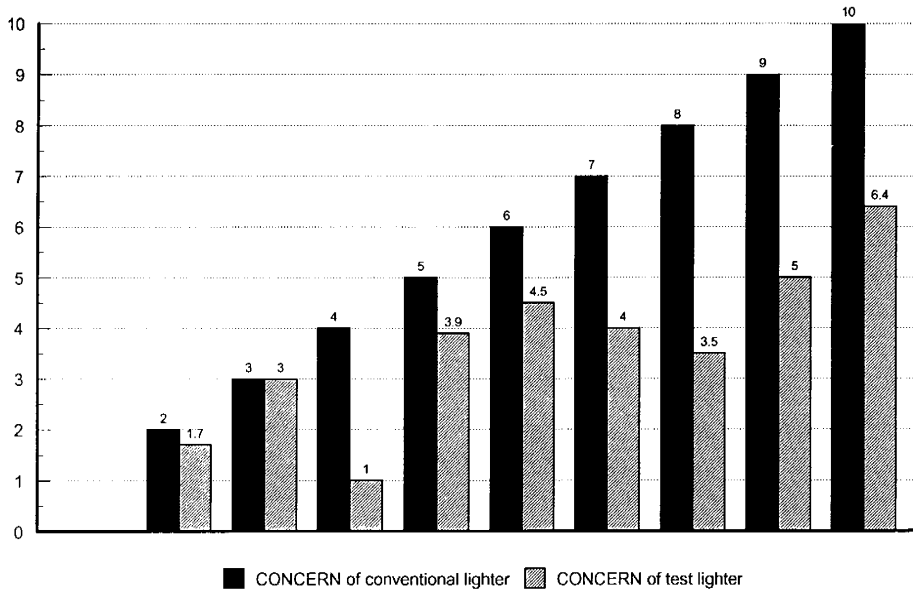


Fig. 1-B. Relation of CONCERN Assessments for Conventional Lighter and Test Lighter.

concern level for the test lighter as being 1. A minority of 8–9% of the population viewed the lighter as being not at all dangerous or posing a risk of concern.

The effect of the child-resistant lighter on risk perceptions at different levels of assessed risk is illustrated in Fig. 1A for the DANGER scale and Fig. 1B for the CONCERN scale. In each case, the baseline risk assessment is indicated by the dark bar. For all respondents who

gave that initial risk value, the cross-hatched bar indicates the value of their assessed risk after the advent of the child-resistant lighter. For example, in the case of both DANGER and CONCERN, the group of individuals who initially rated the lighter on the risk scale with a score of 10 gave the child-resistant lighter a score of 6.4.

The general patterns are quite similar. Individuals who initially believe the risks are the highest had the

Table III. Regression Results for Test Lighter Risk Perceptions

Variable label	Coefficient (SE)			
	ln (DANGER-TEST)		ln (CONCERN-TEST)	
Intercept	-0.38 (0.26)	-0.28 (0.36)	-0.28 (0.39)	-0.28 (0.47)
ln (DANGER/CONCERN- CONVENTIONAL)	0.89* (0.13)	0.88* (0.13)	0.84* (0.18)	0.95* (0.19)
FATHER	—	0.01 (0.10)	—	0.03 (0.11)
COLLEGE	—	-0.04 (0.09)	—	-0.13 (0.10)
MALE-KID	—	0.02 (0.09)	—	-0.11 (0.10)
YOUNG-KID	—	-0.07 (0.09)	—	0.02 (0.10)
BLACK	—	-0.27* (0.13)	—	-0.21 (0.15)
HISPANIC	—	-0.14 (0.18)	—	0.15 (0.20)
INCOME	—	0.002 (0.003)	—	0.002 (0.004)
INCOME>60K	—	0.0002 (0.19)	—	0.08 (0.22)
INCOME-MISSING	—	0.30 (0.37)	—	0.50 (0.42)
SAFETY-CAPS	—	-0.10 (0.11)	—	-0.21 (0.13)
NO-SEAT-BELTS	—	0.11 (0.09)	—	0.16* (0.10)
NYMETRO	—	0.05 (0.12)	—	0.15 (0.13)
CHICAGO	—	0.17 (0.13)	—	0.04 (0.14)
\bar{R}^2	.20	.22	.10	.10

* Statistically significant at the 5% level, one-tailed test.

largest declines in the risk perceptions. In contrast, those who assess risks as lower seem to be much less affected. The principal exception is individuals who have an initial CONCERN rating of 4, which subsequently drops to 1, but the sample size for this particular cell is very thin (i.e., one observation).

The basic result is that there is a larger effect of the child-resistant feature on risk perceptions at the higher end of the scale. One would expect such features to have the greatest effect on safety for those who initially believe the lighters are very risky.

3.3. Regression Results for Risk Perceptions

To explore the determinants of the DANGER and CONCERN levels for respondent *i*, consider the follow-

ing linear regression model:

$$\ln \text{RISK-TEST}_i = \alpha + \beta_1 \ln \text{RISK-CONVENTIONAL}_i + \sum_j \gamma_j \text{Personal Characteristic}_{ij} + u_i$$

where the RISK variable pertains to either DANGER or CONCERN, the dependent variable is the natural logarithm of the risk variable for the test lighter, the principal explanatory variable is the natural logarithm of the risk variable for the conventional lighter, and the other explanatory variables are the personal characteristic variables.

One would expect that respondents with high risk assessments for the conventional lighter design would also have high risk assessments for the test lighter. Since the risk variables are transformed by the natural logarithm, the base risk coefficient β_1 indicates the percent-

age change in the perceived test lighter risk with a 1% change in the conventional lighter risk. If the new mechanism reduces risk perceptions by the same proportion, the estimated β_1 will equal 1.0.

The other explanatory variables consisted of the principal demographic characteristics and two risk attitude measures, usage of seat belts and safety caps. Past studies of risk suggest that these are likely to be the other key measures of concern.¹⁹ Personal characteristics may affect how the child-resistant lighter is used, but the overall effect of personal characteristics on risk perceptions will already be reflected to a large extent through the respondent's initial risk beliefs.

Table III reports the regression results for both DANGER and CONCERN. In each case, the first equation incorporates only the conventional lighter risk assessment and a second equation adds the personal characteristic variables. The coefficient estimates for the prior risk assessment for the conventional lighter imply that the percentage change response in the test lighter risk assessment to a 1% change in the conventional lighter risk ranges from .84 to .95.²⁰

The demographic characteristics have little independent effect on the test lighter risk perceptions that is not already captured through the initial risk beliefs. The two main exceptions are that blacks are more likely to give the test lighter a lower DANGER score, for any given prior risk assessment value, and those who do not wear seat belts expressed significantly higher concern with respect to the test lighter.

Finally, the low explanatory power of the two equations is noteworthy in that the R^2 values range from only .10 to .22. Since these data are microdata, not aggregative data, the fit is relatively low. Since our major concern is with testing the linkage between initial and subsequent risk beliefs rather than forecasting risk perceptions, this result is not disturbing. A greater correspondence between the initial and the test lighter risk assessments might have been established if these questions had been paired in the same questionnaire instead of being asked in different surveys before and after using the test

lighter. The difficulty with pairing the questions in the same survey is that survey respondents may answer the questions less thoughtfully than if they considered the risk perception questions at different junctures.

4. THE PRECAUTIONARY RESPONSE

4.1. Precaution Measures and Mean Effects

To test the precautionary effect of the new mechanism, the survey included measures of both the actual precautions taken and the attitudes toward the need for precautions. The initial set of precautionary measures consists of precaution/placement variables. The first of the two variables that directly address precautions is PRECAUTION, which is a 0–1 dummy variable for whether the respondent indicated that he or she took precautions with respect to the test lighter. This is an open-ended question regarding precautionary behavior. Overall, 88% of the respondents took some type of precaution, but the particular precaution is not specified.

Based on extensive focus-group interviews with other samples of lighter users, we developed a series of specific precautionary questions that would identify the major classes of precautions. The second precaution/placement variable is ACCESS. This variable reflects whether the lighter is within the reach of children, and consequently it is a key summary variable pertaining to the specific precautions that households emphasized in the focus group discussions. Overall, only 7% of the sample left the test lighter in a place where the child could reach it.

The next set of precaution variables consists of a series of precaution/perception variables that reflect general attitudes toward the need for precautionary behavior. The classes of concerns considered here also drew upon the focus group discussions of the factors pertinent to precaution taking. The first of these precaution/perception variables is LESS-CAREFUL, which is a 0–1 dummy variable indicating that the respondent believes that parents in general will be less careful with the test lighter. This question was framed in the third person rather than asking whether the respondent would be less careful so as to elicit potentially more honest responses regarding the subject's own likely action.²¹ Overall, 48%

¹⁹ Since we did not have an inordinate number of variables, it was not necessary to sift through the data with techniques such as stepwise regression. Doing so also is not generally ideal since it is preferable to specify the variables that, on a theoretical basis or based on past studies, should have an effect on risk rather than to sift through the data in a mechanical way. Our objective was to test hypotheses, not to find a variable list that could maximize the fit of our equation.

²⁰ The difference-of-means test statistics are 13.1 for DANGER and 14.03 for CONCERN. These differences are not statistically significant at the usual levels. Moreover, one cannot reject the hypothesis that the elasticity is 1.0.

²¹ Similarly, in the crime literature researchers have found that one often obtains more accurate assessments of the propensities to commit crime if one asks individuals whether their friends commit crime rather than if you ask the survey respondent if he or she engages in crime. See, for example, Refs. 4 and 5.

Table IV. Summary of Probit Estimates for Precautionary Actions^a

Precaution/placement variable	Coefficient (SE)	
	ln (DANGER-TEST)	ln (CONCERN-TEST)
PRECAUTION	0.195* (0.060)	0.197* (0.052)
ACCESS	-0.237* (0.080)	-0.312* (0.088)
LESS-CAREFUL	-0.063* (0.035)	-0.079* (0.031)
LESS-TEACHING	-0.073 (0.049)	-0.029 (0.040)
ON-PERSON	0.082* (0.035)	0.091* (0.032)
LIVING ROOM/KITCHEN	-0.058 (0.039)	-0.068* (0.036)
BEDROOM/BATHROOM	-0.043 (0.039)	-0.014 (0.034)
OTHER-ROOM	-0.081 (0.078)	-0.127 (0.070)
PEACE-OF-MIND	-0.260* (0.050)	-0.141* (0.040)
REDUCE-FIRES	-0.124* (0.035)	-0.076* (0.031)

^a Each equation also includes the following explanatory variables: FATHER, COLLEGE, MALEKID, YOUNGKID, BLACK, HISPANIC, INCOME, INCOME>60K, INCOME-MISSING, CHICAGO, and NYMETRO.

* Statistically significant at the 5% level, one-tailed test.

of the sample believes that parents would be less careful with the test lighter because of its enhanced child resistance.

The next of the precaution/perception variables is a categorical variable for whether subjects agree or disagree that parents will spend less time teaching their children about fires (LESS-TEACHING). This variable will capture adverse spillover effects of the regulation on other fire safety concerns. Overall, respondents still believe that general fire safety instruction is important, but 31% believe that there would be some diminished teaching.

The next set of variables consists of four measures of specific lighter placement. In particular, did the respondent keep the test lighter on his or her person, in the living room/kitchen area, in the bedroom or bathroom, or in some other room? The focus group discussions suggested that keeping a lighter on one's person was a major form of precautionary behavior.

The final set of precaution variables deals more with perceptions than with actual precautionary actions. The first of these is whether respondents indicated that the lighter would provide more PEACE-OF-MIND. In the focus groups, this phraseology was often used in discussing the diminished need for precautions. Overall,

84% of the subjects believed that the test lighter gave them more peace of mind. Similarly, respondents were asked about whether they believed the lighter would reduce fires (REDUCE-FIRES).

4.2. Econometric Analysis of Precaution Taking

The various precaution variables are dichotomous 0–1 precaution choices. Conventional regression techniques do not take into account the limit on the precaution probability, which is bounded by 0 and 1. To reflect this constraint on the dependent variable, we utilized probit regressions, which explicitly account for the probability being bounded between 0 and 1. This approach assumes the error term is normally distributed.

In assessing the influence of the respondents' risk perceptions on precautionary behavior, we made the probability of each precaution a function of the set of demographic variables listed at the bottom of Table IV as well as either the DANGER-TEST variable or the CONCERN-TEST variable. The different precaution/placement variables appear in the first column in Table IV, and the next two columns give the estimated effects

Table V. Estimated Effects on Precautions of Changes in DANGER (a) and CONCERN (b) Assessments

Precaution/placement variable	Conventional lighter		Test lighter		Comparison: conventional - test	
	Mean	SE	Mean	SE	Diff. of means	Test statistic ^a
	a					
PRECAUTION	0.958	0.004	0.875	0.009	0.083	8.427
ACCESS	0.018	0.003	0.069	0.009	-0.051	5.376
LESS-CAREFUL	0.400	0.009	0.475	0.009	-0.075	5.893
LESS-TEACHING	0.091	0.007	0.130	0.010	-0.039	3.195
ON-PERSON	0.553	0.010	0.428	0.011	0.125	8.408
LIVING ROOM/KITCHEN	0.697	0.012	0.750	0.011	-0.053	3.256
BEDROOM/BATHROOM	0.206	0.009	0.243	0.010	-0.037	2.750
OTHER-ROOM	0.032	0.003	0.050	0.005	-0.018	3.087
PEACE-OF-MIND	0.644	0.014	0.835	0.013	-0.191	9.997
REDUCE-FIRES	0.324	0.009	0.466	0.012	-0.142	9.467
	b					
PRECAUTION	0.951	0.005	0.875	0.010	0.076	6.798
ACCESS	0.019	0.005	0.069	0.010	-0.050	4.472
LESS-CAREFUL	0.385	0.010	0.475	0.010	-0.090	6.364
LESS-TEACHING	0.114	0.008	0.130	0.009	-0.016	1.329
ON-PERSON	0.532	0.011	0.429	0.012	0.103	6.327
LIVING ROOM/KITCHEN	0.687	0.013	0.750	0.011	-0.063	3.699
BEDROOM/BATHROOM	0.232	0.009	0.244	0.010	-0.012	0.892
OTHER-ROOM	0.026	0.003	0.050	0.005	-0.024	4.116
PEACE-OF-MIND	0.722	0.012	0.834	0.010	-0.112	7.170
REDUCE-FIRES	0.378	0.009	0.466	0.010	-0.088	6.541

^a Difference of means test calculated as (MEAN-conventional - MEAN-test) divided by square root of sum of square of standard errors of mean.

of the risk perception variables, where each of these has been estimated with separate equations.

The results in Table IV are quite strong and similar for each of the risk perception variables. Increases in DANGER perceptions or safety CONCERN boost the probability of taking some type of precaution and decrease the probability that the lighter will be accessible to children. Similarly, an increase in the risk perception for the test lighter diminishes the probability that the respondent believes that other parents will be less careful with the lighters. The estimated coefficients for the effect of the two risk perception variables on teaching about fire safety are not statistically significant at the usual levels. Concern over general fire safety will remain present.²²

²² It should be noted, however, that the absence of an effect may also reflect the limitations of the sample size of 200. It should also be noted that the coefficient of DANGER-TEST in the LESS-TEACHING probit equation is significant at the 10% level.

The next set of variables in Table IV pertains to the specific placement of the lighter within the household. Most dramatically, higher DANGER or CONCERN values for the test lighter increase the likelihood that the respondents kept the lighter on their person rather than leaving it in one of the rooms of the house. The only other nonplacement effect that is statistically significant at the 95% confidence level is that there is a negative effect of CONCERN with safety on placement in the living room and kitchen areas. The focus-group discussions indicated that this part of the house was frequently used by children.

The final set of variables consists of the need for taking precautions. Individuals who have higher risk perceptions are less likely to believe that the test lighter provides more PEACE-OF-MIND. Similarly, increases in risk perceptions make it less likely that the respondents will believe that the lighter will reduce fires, which in many respects can be viewed as a consistency check on the risk perception variable as well as a measure of

the net influence of precautions and the child-resistant feature.

The influences estimated in Table IV are consistent with the hypothesized linkage between risk perceptions and precautionary behavior. Chief among these is that children's access to the lighters will change, and people will be less likely to keep the lighter on their person. However, fire hazards will continue to be a risk that parents will teach to their children.²³

4.3. Magnitude of the Effects on Precautions

Although the great majority of the linkages discussed with respect to Table IV pertain to statistically significant relationships, these effects may not be of substantial magnitude. By linking Section 3's results pertaining to the change in risk perceptions with the precautionary behavior regressions, it is possible to estimate how important the precautionary behavior effect is.

The procedure that was used was the following. For each observation in the sample, using the probit estimating equations that were the basis for the results in Table IV, we calculated the predicted probability that the individual would take the precaution given the assessed risk value for the test lighter.²⁴ The mean value of this predicted precaution, taking probability as well as the standard error of the mean calculated over the 200 observations, appears in the middle section of Table Va for DANGER perception and Table Vb for CONCERN. We then replaced the value of the test lighter risk perceptions by the risk belief value—either DANGER-CONVENTIONAL or CONCERN-CONVENTIONAL. After making the substitution, we calculated the probability based on the estimating equations underlying Table IV that the individual would take the particular precaution if risk beliefs had not changed. The results for the conventional lighter precautions appear in columns 2 and 3 in Table Va for DANGER and in columns 2 and 3 in Table Vb for CONCERN.

The extent of the difference in precautions is calculated in the final pair of columns in Tables Va and Vb. The second-to-last columns provide the difference in the means, and the final columns give the test statistic

²³ This result differs from that for safety caps, for which there was evidence of adverse external effects on precaution taking for risky products without caps.

²⁴ Because of the nonlinearity of the probit estimation technique, the procedures below were carried out on an observation basis rather than simply using the mean values of the explanatory variables.

pertinent to the difference of means test. The difference of means is statistically significant at the 5% level in all cases except for the two CONCERN results pertaining to LESS-TEACHING about the risks of fires and placement in the BEDROOM/BATHROOM.

The magnitudes of the effects are of particular interest. Since the sizes of the effects are similar for DANGER and CONCERN, we focus on the DANGER results. The advent of the test lighter will decrease the likelihood of taking precautions by .08, will increase the chance of children's access to the lighters by .05, will increase the probability that people will become less careful by .08, will increase the likelihood that there will be less teaching about fires by .04, will decrease the chance that the person keeps the lighter on their person by .13, and will increase the probability that the lighter user will have peace of mind and not worry about fires by .19. None of these effects is trivial. The key safety policy issue is whether the safety gains resulting from the new design are even greater.

5. IMPLICATIONS FOR LIGHTER SAFETY

The baseline for calculating the effect on lighter safety is the lighters' current risk of injury. For the population of children affected by lighters, we estimate this annual probability to be 2.23×10^{-5} .²⁵ Column I in Table VI uses this average baseline probability as the base risk level to be used as the reference point to assess the effect on lighter safety.

One can view the risk of injury as being the result of three linkages:

$$\text{Risk of Injury} = \frac{(\text{Probability of no precaution}) \times (\text{Probability that start fire|no precaution})}{(\text{Probability of injury|start fire})} \quad (1)$$

In the absence of a change in precautions, the efficacy of the child-resistant feature will be driven by the change in the probability that children will be able to

²⁵ This calculation is based on injury reports to the Consumer Product Safety Commission on the number of fire-related injuries to children aged 0–14, where this overall injury level is divided by the total population in that age group. Although this age span is broader than is ideal, if the risk distribution is uniform across the age distribution then the overall risk level will not be distorted. More importantly, the analysis that follows is concerned primarily with whether the risk level will increase or decrease based on the net influence of the technological improvement and the precautionary response. The answer to this general issue is independent of the specific risk level, although the magnitude of the effects being considered will clearly be affected by the injury risk.

Table VI. Change in Probability of Fire Based upon Precautionary Behavior

Precaution/placement variable	Conventional lighter		Test lighter		Lighter differences		
	(1) Current probability of injury	(2) Conditional probability of injury given start lighter	(3) Probability of injury if no change in precautions	(4) Probability of injury given precautionary response	(5) Change in probability of injury (test—conventional)	(6) Effect of moral hazard on probability of injury	(7) Ratio: moral hazard to change in probability
PRECAUTION	2.23E-05	1.40E-03	2.93E-06	8.73E-06	-1.36E-05	5.80E-06	0.4277
ACCESS	2.23E-05	3.26E-03	2.93E-06	1.12E-05	-1.11E-05	8.32E-06	0.7526
LESS-CAREFUL	2.23E-05	1.47E-04	2.93E-06	3.48E-06	-1.88E-05	5.54E-07	0.0295
LESS-TEACHING	2.23E-05	6.45E-04	2.93E-06	4.19E-06	-1.81E-05	1.26E-06	0.0697
ON-PERSON	2.23E-05	1.31E-04	2.93E-06	3.75E-06	-1.85E-05	8.25E-07	0.0445
LIVING ROOM/KITCHEN	2.23E-05	8.42E-05	2.93E-06	3.16E-06	-1.91E-05	2.27E-07	0.0119
BEDROOM/BATHROOM	2.23E-05	2.85E-04	2.93E-06	3.46E-06	-1.88E-05	5.31E-07	0.0282
OTHER-ROOM	2.23E-05	1.83E-03	2.93E-06	4.58E-06	-1.77E-05	1.65E-06	0.0934
PEACE-OF-MIND	2.23E-05	9.11E-05	2.93E-06	3.80E-06	-1.85E-05	8.74E-07	0.0473
REDUCE-FIRES	2.23E-05	1.18E-04	2.93E-06	4.22E-06	-1.81E-05	1.29E-06	0.0714
REGULATE	2.23E-05	8.92E-05	2.93E-06	3.26E-06	-1.90E-05	3.25E-07	0.0171

start a fire given that parents do not take precautions. Let this probability be the probability that the child is able to operate the lighter successfully within two 5-min test periods—the first without a demonstration, the second following a demonstration. In the case of the conventional lighter, this figure is 38%, and for the test lighter the probability of being able to operate the lighter is 5%. Thus, if there is no change in precautionary behavior, the test lighter reduces the risk of fire-related injury to $(5/38)(2.23 \times 10^{-5})$, or a value of 2.93×10^{-6} . This probability of fire from the conventional lighter if there is no change in precautions appears in the third column in Table VI.

Inspection of Eq. (1) also highlights the principal components of assessing the change in the risk of injury. In the case of the conventional lighter, the fire-related risk of injury on the left side of the equation is known. The probability that an individual does not exercise each precaution can be ascertained for all of the 10 measures of precautions using the results in Table V. The probability that the child will start a fire given no precaution is .38 for the conventional lighter and .05 for the test lighter. The only unknown in the equation is the probability of an injury given that the child is able to start a fire. This probability will be calculated for each of the different precautionary measures since the context in which the child starts the fire may differ depending on the particular precaution. Thus, for the conventional lighter, the equation for the first precaution question is

$$2.23 \times 10^{-5} = (.042)(.38)(\text{Probability of injury|start fire})$$

or

$$(\text{Probability of injury|start fire}) = 1.40 \times 10^{-3}$$

In a similar manner, one can calculate the conditional probability of injury given that the child successfully operates the lighter for each of the precaution measures, and these appear in column 2 in Table VI.

The next issue is to determine the probability of injury from the test lighter given the precautionary response. Using the probability that the individual does not take the particular precaution (based on the results in Table V) in conjunction with the .05 probability that the child will start a fire given no precaution and the probability of injury given that the child starts a fire (based on the results in column 2 in Table VI), one calculates the risk of the test lighter as in the following example of the first precaution variable in Table VI:

$$\text{Risk of injury} = (.125)(.05)(1.40 \times 10^{-3}) = 8.73 \times 10^{-6}$$

In a similar fashion, one can calculate the probability of injury for the other precautionary responses, leading to the results in column 4 in Table VI.

Is the net effect an increase or a decrease in safety? Subtracting the results in column 1 from column 4 yields the change in this risk probability, which appears in column 5 in Table VI. For the first two precaution variables—the overall PRECAUTION variable and the ACCESS to children variable—the net reduction in risk from the child-resistant feature is 1×10^{-5} , or half of the initial risk level. In contrast, for the other measures of precautions, the net safety effect of the test design is even greater, decreasing the fire injury risk by as much as 85%.

Two features of these results are most noteworthy. First, the measures that were constructed in a manner that was most directly related to precautionary behavior are the first two variables. Second, each of the two smaller safety effects is based on underlying precaution regression results that have statistically significant risk coefficients, whereas the underlying regression estimates pertaining to LESS-TEACHING and the various room placement decisions were often not statistically significant, so that less confidence can be placed in them.

The final matter of interest is the effect of diminished precautions on the probability of injury. These effects are summarized in the final columns in Table VI. Column 6 indicates the absolute effect of decreased precautions on the probability of injury, and column 7 presents the ratio of this effect to the change in the probability. In the case of the precaution and access decisions, the effects range from 43 to 75% of the size of the net reduction in the risk level. For most of the other variables, the precautionary effect is under one-tenth of the size of the change in the risk. In all cases the role of diminished precautions is nontrivial, and for the two key precaution measures the effect is quite large.

6. CONCLUSION

The role of diminished safety precautions in response to regulations has long been controversial. Based on this detailed assessment of consumer responses to child-resistant features for cigarette lighters, it has been possible to document in detail the underlying behavioral mechanisms that give rise to the observed response.

The first mechanism is that technological enhancements to product design have the expected effect of lowering consumers' perceptions of product-related risks. There is no evidence in this particular context that this decrease in risk perceptions exceeds the actual decrease in risk, although this may not be the case in other situations.

The reduction in risk perceptions influences the ultimate risk levels associated with the product because consumer precaution measures are strongly linked to the risks they perceive for the product. Analysis of a wide variety of precaution measures indicates that the effort consumers make to decrease the risk associated with the product is strongly linked to the perceived risk level. These results consequently strongly link the behavioral response to the change in risk perceptions.

The empirical findings also made possible an explicit calculation of the magnitude of the precautionary effect and its relationship to the overall product safety.

In two notable instances—for measures of precaution taking generally and the decision to prevent children from having access to lighters—the magnitude of the precautionary effect was quite sizable. For the remaining measures, such as explicit measures of the placement of the lighter, the effects were not as strong, although the decreased care did raise the level of the product risk. The divergence of the responses may indicate that different types of precautions may be affected in different ways by the advent of child-resistant features. In the absence of additional information that explicitly links these particular precaution measures to actual safety outcomes, it is not possible to make any definitive judgments as to which of the results are most compelling.

Overall, these findings suggest that the effect of regulations on precautions cannot be dismissed as a theoretical curiosity. Fire safety education should remain a continuing concern. However, on balance, the safety improvements made possibly by this lighter safety device far outweigh the effect of diminished care.

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