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ARTICLE

The Broad Impacts of Disposable Lighter Safety Regulations

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Abstract

The Consumer Product Safety Commission's regulation of disposable lighters was targeted at preventing injuries due to use of lighters by children not over 4 years of age. Based on a difference-in-differences analysis of national data for 1990–2019, this article estimates that the regulation reduced all injuries to the target population by 71%, burn injuries by 74%, and injuries severe enough to warrant admission to the hospital by 85% overall and by 84% for burn injuries. Unlike the counterproductive performance of safety cap regulations, this safety device enhanced safety levels in the target population group. The safety improvements from lighter safety devices outweigh any lulling effect of viewing products as being "childproof." The regulation had a broader safety impact beyond the target population group, as it also reduced all types of injuries by at least 50% for children in the 5–17 age groups. Total annual risk reduction benefits were $940–$1465 million. A benefit-cost analysis based on a retrospective assessment of the regulation finds a more favorable impact than was anticipated.

1. Introduction

Government safety regulations often focus on protecting young children, as in the case of child safety seats, crib standards, and minimum size requirements for components of toys. Some regulations for very young children also may have broader effects on other population groups. Safety cap regulations are intended to reduce child poisonings, but they also been found to have wider impacts in terms of the effort adults must expend to open the caps. The public also may overestimate the efficacy of the safety device, treating the reduced risk product as being "childproof," which in turn may make them laxer about access of such products to children, potentially undermining the safety benefits. To assess the safety impacts of disposable lighter safety regulations, this article presents a retrospective assessment of the impact of this regulation using a difference-in-differences analysis of several injury measures. The assessment considers both the risk impacts on the target age group of very young children as well as any additional safety impacts on older children. Unlike the

performance of safety cap standards, lighter safety regulations have significantly reduced injuries to the target age group. An additional dividend is that the regulation reduced injuries to older children as well.

There are two principal rationales for child safety regulations. First, young children have greater physical vulnerability and are often at high risk, but they are not well-equipped to assess and implement appropriate degrees of care. Second, some studies have suggested that reducing risks to the lives of children should command a premium compared to risks to adults (Maguire *et al.,* 2004; Hammitt & Haninger, 2010; Blomquist *et al.,* 2011; Byl, 2013; Williams, 2013; Hammitt & Herrera, 2018; Robinson *et al.,* 2019). For example, recent regulations to require rear-view cameras in motor vehicles were motivated by a desire to prevent drivers from inadvertently backing up over young children. The National Highway Traffic Safety Administration's (NHTSA) regulatory impact analysis for this regulation observed that because the lives of young children were involved, the value attached to these mortality risk reductions should exceed the standard estimates of the value of a statistical life (VSL) (Sunstein, 2014, 2019).

Since the effects of the Consumer Product Safety Commission's (CPSC) regulations for young children have not always been favorable, there was no assurance that lighter safety devices would have their intended effect if counterproductive influences similar to those for safety caps were operative. The risk reduction impacts of safety devices are partially diminished because it is rational to take less care if products become less dangerous (Peltzman, 1975; Blomquist, 1988, 1991). Augmenting such impacts is the influence of misperceptions regarding the efficacy of safety devices. Viscusi (1984, 1985) found that safety cap regulations for a wide range of products did not enhance safety, in part because they induced a lulling effect whereby people overestimated their impact on safety. Products with safety caps were incorrectly characterized as being "childproof" even though the test protocols for the product did not require 100% efficacy. The effort involved in opening containers with safety caps also led some parents to leave the caps off the bottles, which would make the product more likely to poison children by making the product more readily accessible.

Because of the importance of lighter-related risks to children and a concern that lighter safety mechanisms would fall into the safety cap trap of having a counterproductive effect if parents became sufficiently lax about safety, the lighter manufacturer BIC commissioned a study to monitor the impact of placing test lighters in households with young children. This 1990 field study, which was subsequently published in Viscusi and Cavallo (1994, 1996), distributed test lighters with the safety mechanisms to 200 households with young children in New York, Chicago, and Memphis. The authors' longitudinal survey obtained information before and after the placement of the test lighter regarding parents' concern with safety, the placement of lighters, and children's access to the lighters. They also developed a test protocol for whether children could activate the lighter after an in-house placement. As part of this test protocol, the children were shown how to operate lighters without the child-resistant mechanism, which 38% of the children were able to do. Their protocol for the child-resistant lighters was similar to the test protocol that was later adopted by the CPSC. Only 5% of the children succeeded in operating the test lighter with the child-resistant mechanism, which is 87% lower than the fraction who could operate lighters without the safety device.

Lighter safety will also depend on the degree to which children have access to the lighters. There was evidence that parents became laxer about children's access to lighters with safety mechanisms, consistent with a lulling effect. More than 80% of the sample of parents agreed either somewhat or strongly that child-resistant lighters would give greater peace of mind

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and make lighter safety discussions with their children less necessary, and 48% believed that parents would be less careful with lighter placement because of child resistance (Viscusi & Cavallo, 1994, 1996). After the use of child-resistant lighters, parents' perceptions of danger from lighters declined by 38%, and concern with safety declined by 37% (Viscusi & Cavallo, 1994). Despite the perception of greater inherent product safety and the decreased belief that it was important to exercise care in the placement of the lighters, the pilot design of the child-resistant device was sufficiently difficult for children to operate that it would have a net safety-enhancing effect. The authors projected that it would decrease injuries to children by 50–85%, which is a range that brackets the estimated impacts found below.

In 1994, the CPSC implemented a national standard requiring safety mechanisms on disposable lighters. Subsequent regulations broadened the requirements for other lighter types, such as multipurpose lighters.[1] Section 2 provides a discussion of the background of the regulation and the regulatory impact analysis prepared by the agency, detailing the costs and the expected impacts of the regulation on child safety. Section 3 discusses the lighter safety data and presents the statistical analysis of the risk-related impacts. Available national data on different types of injuries specifically linked to lighters are available by age group, making it possible to estimate the impacts on the target population group as well as older children. Based on the monetized value of the benefits presented in Section 4, the lighter safety regulations generated benefits exceeding those that were anticipated. Section 5 offers policy-relevant conclusions.

2. Background

The CPSC enacted the lighter safety regulation to take effect on 12 July 1994.[2] The specified goal of the regulation was to make all disposable and novelty lighters resistant to operation by children under the age of 5. There are no conflicting or overlapping regulations which could have had an effect on children's lighter-related injuries and whose implementation coincided with that of the CPSC rule. The rule would cover about 98% of all lighters that consumers use. The test protocol for whether the lighter had a sufficiently protective safety mechanism involves use of at least one but not more than two panels of 100 children each who have 5 min to attempt to successfully operate the lighter. If they fail to get a flame from the lighter, they are given two visual demonstrations of the operation of the lighter followed by another 5-min period during which they attempt to operate the lighter. If no more than 10 children in the first panel successfully operate the surrogate lighter, it is approved with no further testing. If 11–18 children successfully operate the lighter, the test results are inconclusive, and the surrogate lighters are tested with the second panel. If over 19 children can operate the lighter in this test, the surrogate lighter is not child-resistant. If a second test is required, the lighter is considered child-resistant if no more than 30 children in the combined first and second panels (85%) can operate the surrogate lighter. For a device to be characterized as child-resistant, it must be resistant to operations by young children for at least 85% of the subjects. If the children who are able to circumvent the safety feature are

[1] 16 CFR Part 1212. Safety Standard for Multi-Purpose Lighters. Available at https://www.govinfo.gov/content/pkg/FR-1999-12-22/pdf/99-32677.pdf. 64 FR 71872.

[2] 16 CFR Part 1210. Safety Standards for Cigarette Lighters. Available at https://www.law.cornell.edu/cfr/text/16/part-1201. 58 FR 37554.

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more intelligent, they may better understand the safety risks and be less likely to create fire hazards. However, by design, the standard did not ensure that lighters would be "childproof" despite the frequent labeling of such lighters as being "childproof" (Associated Press, 1993). Nevertheless, the 1993 Associated Press article that appeared in the *New York Times* announced the forthcoming standard with the headline: "Lighters Required to Be Child-Proof." More recently, as of January 2022, the BIC Store on Amazon advertises "Child Proof-Safety" lighters, and websites provide how-to guides for using "childproof" lighters (Gargulinski, 2017; BIC, 2021).

The CPSC estimated that the regulation would generate injury reduction benefits of $210–$270 million annually.[3] The most consequential health impacts of the regulation would be a reduction of 150 deaths annually, where 80–105 of these deaths are for children under 5. The CPSC also estimated that there would be a reduction in nonfatal injuries, which had averaged 1100 annually from 1988 to 1990. The regulatory impact analysis valued each death at $2 million and did not specify the value used for injuries. In addition to safety benefits, there would also be a reduction of $70 million in property damage. Based on the test protocol format and the test performance of the pre-regulation lighters, CPSC assumed that the rule would reduce the $385 million in annual losses by 70%, generating annual benefits of $269.5 million.[4] The 70% figure is just above the midpoint of the range of the estimated impacts based on the field test by Viscusi and Cavallo (1994, 1996). Below we explore different measures of impact of the regulation to provide an *ex post* regulatory impact assessment of whether the 70% projection was borne out.

The anticipated annual benefits of the regulation are about three times greater than the annual costs of $90 million per year. The principal cost component is that of developing, producing, testing, and certifying lighters, which would be $50 million incurred over a period of 2–3 years and amortized over years of lighter production. The recurring production-related variable costs would be about $20 million annually. The agency did not monetize the increased costs to consumers of operating the lighters with the safety mechanism. CPSC estimated the annual net benefits to be $115–$180 million.

3. Statistical analysis

3.1 Background and data description

The previous literature on the efficacy of lighter safety has consisted of both prospective analyses and an examination of their actual injury impacts. Based on their prospective field study that monitored lighter placement and children's success in overcoming the safety mechanisms, Viscusi and Cavallo (1994, 1996) estimated that the BIC lighter resistance design would reduce injuries by 50–85% notwithstanding the increased access that children

[3] Consumer Product Safety Commission, Safety Standard for Cigarette Lighters, 58 FR 37564. Available at https://www.govinfo.gov/content/pkg/FR-1993-07-12/pdf/FR-1993-07-12.pdf.

[4] The genesis of the 70% figure is that lighters passing the test protocol are required to have at least 85% resistance by young children. The previously marketed "non-child-resistant" disposable lighters were tested to be resistant to operation by 50% of children. The 85% acceptance criterion consequently could reduce losses due to use by young children by (85–50%)/(50%) = 70%. Consider the following example. Suppose that the base case for operable lighters is 2000 injuries. Standard lighter designs would reduce this amount to 1000 injuries. Lighters with 85% efficacy would reduce the 2000 injuries to 300 injuries. The net improvement relative to the pre-regulation lighter design is 700 injuries out of 1000, or 70%.

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would have to lighters. The CPSC's 70% estimate of the efficacy of the lighter regulation was based on the test protocol structure but did not account for actual behavior of the children or the parents. The article by Smith *et al.* (2002) used data from a sample of fire departments over the 1997–1999 period compared to the 1985–1987 period comparing the difference in accident rates for the target age group to that of older children. They estimated a 58% decline in lighter-related injuries among children under 5 after the implementation of the regulation. Our study differs in that it uses a different national database, a longer time period of analysis that includes time periods before and after the advent of the regulation, three measures of lighter-related injuries, a difference-in-differences approach, and estimates of impacts beyond the target age group.

The CPSC operates the National Electronic Injury Surveillance System (NEISS), which is a database of consumer product-related injuries based on a stratified national probability sample of 100 USA emergency room departments.[5] Estimates are projected to national totals based on the NEISS sampling weights. The NEISS dataset includes detailed information on the nature of the injury and the victim. The specific components of the data that are pertinent to our analysis include information on the date of the injury, the consumer product(s) associated with the injury, the age of the victim, the nature of the injury (i.e., whether it was a burn injury), and the disposition of the patient (treated and released, or treated and admitted for further treatment either at the admitting hospital or after being transferred to another hospital). It was feasible to identify burn cases using the diagnosis "burns, thermal." The four different injury outcomes that we considered were all injuries, burn injuries, all injuries that led to hospitalization, and burn injuries that led to hospitalization.

The focus on injuries reported to hospital emergency rooms will lead to a potential understatement of lighter-related injuries such as those that do not require hospital emergency room treatment and injuries that are the result of externalities caused by lighters.[6] The 2022 fire in the Philadelphia rowhouse that killed 12 people was the result of a young child playing with a lighter near a Christmas tree, but would not be captured in measures of lighter-related injuries treated by hospital emergency rooms (Kasakove *et al.*, 2022; Robertson, 2022). Since the child involved in this fire was 5 years old, which is just above the age 4 cutoff for the focus of the regulation, there clearly is not a cliff in potential risk levels that occurs at age 5.

The NEISS data used in our analysis include all cigarette lighter injuries presented to NEISS emergency departments between 1 January 1990, and 31 December 2019. Data from 1990 to 1996 were obtained using a FOIA request, and data beginning in 1997 are publicly available. Lighter-related injuries treated at home or by other health care

[5] The CPSC defines a consumer product as "any article, or component part thereof, produced or distributed:

(i) for sale to a consumer for use in or around a permanent or temporary household or residence, a school, in recreation, or otherwise, or

(ii) for the personal use, consumption or enjoyment of a consumer in or around a permanent or temporary household or residence, a school, in recreation, or otherwise…"

15 U.S.C. § 2052(a)(5). Under section 3(a)(2) of the Consumer Product Safety Act, a children's product means a consumer product designed or intended primarily for children 12 years of age or younger.

[6] CPSC estimates of injuries and associated costs, generated using the CPSC's NEISS and Injury Cost Model (ICM) in conjunction with Consumer Product Safety Risk Management System (CPSRMS) incidents, would not be expected to understate lighter-related injuries, as these tools generate estimates of the number of fatal and nonfatal injuries and associated costs in all treatment settings.

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providers, such as HMO's, are not included. For our sample period, the average annual number of lighter injuries was 2873 (all injuries), of which 2154 were burn injuries. Although all injuries in the dataset were treated by emergency departments, not all patients were hospitalized for further treatment. On average, there were 340 injuries annually that led to hospitalization, of which 286 were burn injuries. In terms of the injury categories that we use in the analysis below, burn injuries comprise a subset of overall injuries, and burn injuries leading to hospitalizations comprise a subset of all hospitalizations. Some lighter-related injuries could be classified as not being burn-related if they involved multiple health impacts, involved harms such as anoxia from smoke inhalation, or were not specifically categorized as being burn injuries but just recorded without indicating the nature of the injury. There was one recorded lighter-related death at the hospitals during the sample period. Our empirical analysis distinguishes three groups of patients suffering lighter-related harms: children under 5, children ages 5–17, and adults. To convert the total injury statistics into rates, we divided by the age-specific population (Population Division, U.S. Census Bureau, 2021).

Table 1 presents information in Panel A on the injury rates in the pre-regulation period from 1990 to 12 July 1994, and Panel B presents the rates in the post-regulation period that extends through 2019. The targeting of the regulation for children under age 5 is appropriate, as their injury rate of 5.3 per 100,000 is just over double that for those ages 5–17, for whom the rate is 2.6, and it is almost five times the rate of 1.1 per 100,000 for adults. For young children, 76% of all injuries involve burns. Burns comprise a dominant share of that group's total admitted injury rate of 0.4 per 100,000, as 95% of these injuries involve burns.

The statistics in Panel B of Table 1 indicate the stark drop in all categories of lighter-related injuries. The total injury rate for youths dropped by 78%, and the rate for the age 5–

Table 1. *Annual injury rates before and after the regulation.*

Panel A. Pre-regulation injury rates			
	(1)	(2)	(3)
Injury rates pre-12 July 1994 (per 100,000)	Children under 5	Age 5–17	Adults
Total injuries	5.34	2.61	1.14
Burn injuries	4.04	2.29	0.79
Total admitted injuries	0.41	0.28	0.08
Admitted burn injuries	0.39	0.20	0.06
Panel B. Post-regulation injury rates			
	(1)	(2)	(3)
Injury rates post-12 July 1994 (per 100,000)	Children under 5	Age 5–17	Adults
Total injuries	1.16	1.30	0.72
Burn injuries	0.78	1.11	0.51
Total admitted injuries	0.08	0.19	0.09
Admitted burn injuries	0.07	0.19	0.07

Note: Admitted, treated and admitted or treated and transferred.

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17 group declined by 50%. The decline for adults is much less and is only 37%. Wholly apart from the role of lighter safety mechanisms, one would expect there to be some decrease in the lighter-related injuries over that time period. The dominant market for disposable lighters is for use in lighting cigarettes. Although there is not available information on lighter sales, the sales of cigarettes declined by 56 % from 1993 to 2019 (Federal Trade Commission, 2021). Smoking rates among adults similarly declined by 44% (from 25 to 14%) over that period. (Centers for Disease Control and Prevention, 1994, 2020).

Figure 1 presents the trends by year in the different injury rates for the under 5 population. Panel A presents the overall injury rates, Panel B presents the burn injury rates, Panel C presents the rates of injuries leading to hospitalization, and Panel D restricts these hospitalized cases to burn injuries. The hospitalization case trends are most volatile and least reliable because of the small numbers of such cases that are projected to national statistics. The vertical red lines indicate the start of the regulatory period. In each of the charts, there is no evidence of a downward trajectory in injury rates before the advent of the regulation. Usually, the rates are rising over time and then followed by a decline in rates after the implementation of the regulation. The post-regulation trajectory of rates exhibits a decline without any resurgence to the pre-regulation rate level.

The statistics for the 5–17 population shown in Figure 2 follow a very similar pattern of rising injury rates in the pre-regulation period followed by an immediate drop and a modest decline thereafter. The principal difference between the 5–17 age group pattern and that for the under 5 population is the level of the rates. The rates in Figure 2 are consistently lower than in Figure 1 but exhibit the same trajectory.

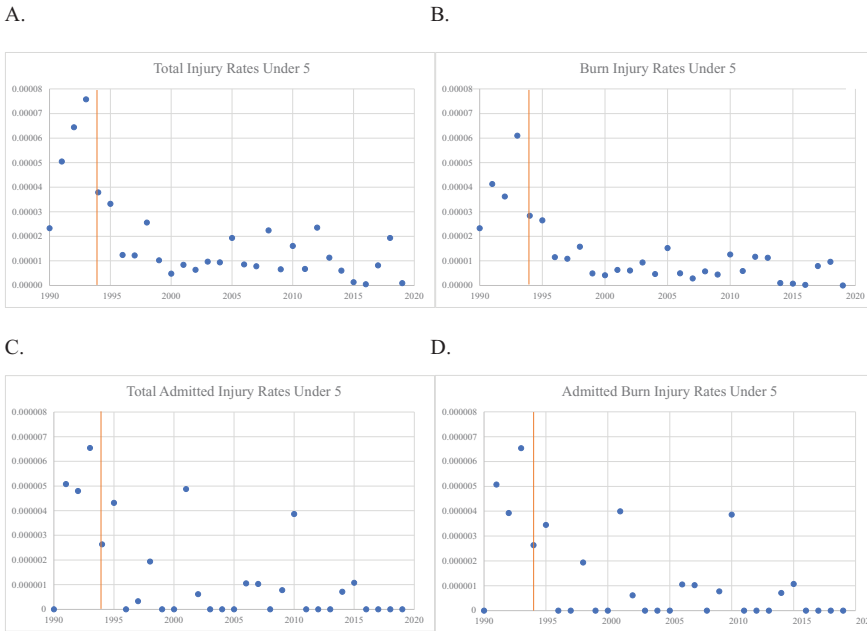

Figure 1. *Lighter injury rate trends for children under 5 by injury type.*

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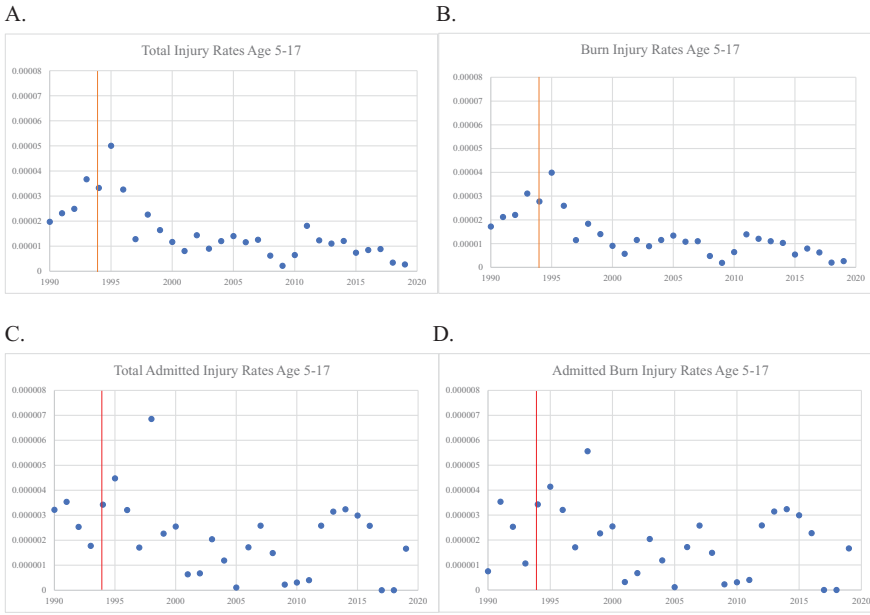

Figure 2. *Lighter injury rate trends for children age 5–17 by injury type.*

The final Figure 3 for the adult population uses a different vertical axis scale to illustrate the trend in injury rates because of the lower level of these injury rates. Injury rates are lower in the post-regulation period, but with a much flatter trajectory than for the other age groups.

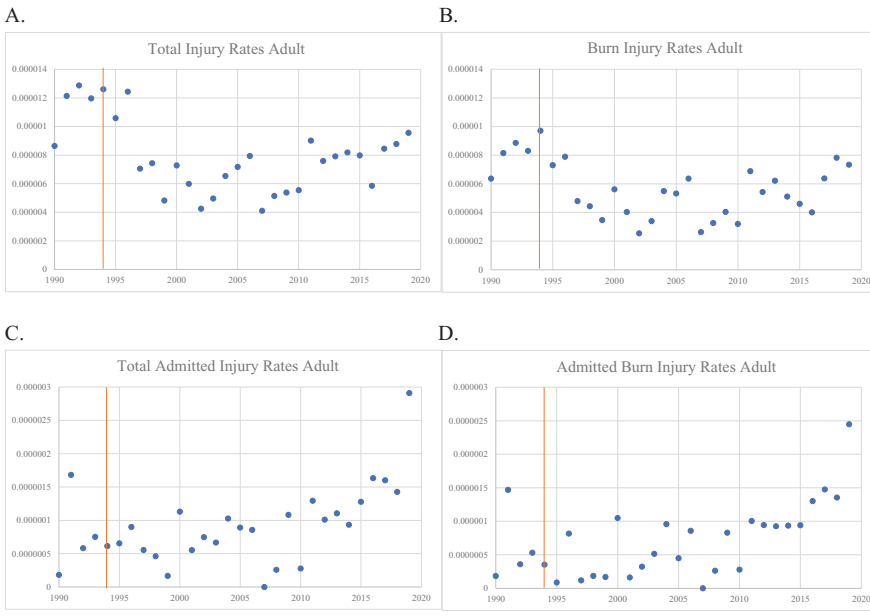

Figure 3. *Lighter injury rate trends for adults by injury type.*

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3.2 The empirical model

The empirical analysis of the impact of the regulation will use a difference-in-differences model. To analyze the injury rates for the under 5 population, we will use two different reference points for what the trajectory would have been in the absence of the regulation, the injury rate trend for adults and the injury rate trend for the 5–17 age group. Because the regulation may have reduced the injury rates for the 5–17 age group, we also analyze the impact of the regulation for this age group using the injury rate trajectory for adults as the reference point. Thus, the principal assumption is that the trend in lighter-related injuries for the under 5 population and for the 5–17-year-old age group would have followed the same pattern as that for the adult population in the absence of the regulation.

For this approach to be appropriate, the pre-regulation trends in injury rates should be similar across the different age groups. For the data series based on a substantial number of injuries, such as the overall injury rates, there is a similar rising pattern of injury rates in the pre-regulation period. Since there are only four pre-regulation observations, to explore the similarity of these trends we calculate the ratio of the injury rate in 1993 relative to that in 1990, which provided a measure of the percentage change in injury rates in the pre-regulation period. Total injuries provide a more meaningful measure of the trend than do injuries requiring treatment after hospitalization, for which there are far fewer observations. For the three different age groups, the 1993–1990 injury rate ratio value exceeds 1.0. It has a value of 3.25 for the under 5 population, 1.86 for those in the 5–17 age range, and 1.38 for adults. None of the ratios is significantly below 1.0, which would have indicated a decline in the risk level in anticipation of the regulation. The ratios are not significantly different from each other, which serves as a measure of the difference in the pre-regulation period slopes.

Figure 4 shows the injury rates in the pre-regulation 1990–1993 period for each age group: children under 5, children 5–17, and adults, from 1990 to 1993. Figure 4 provides a visual demonstration that injury rates were not already declining prior to the regulation.

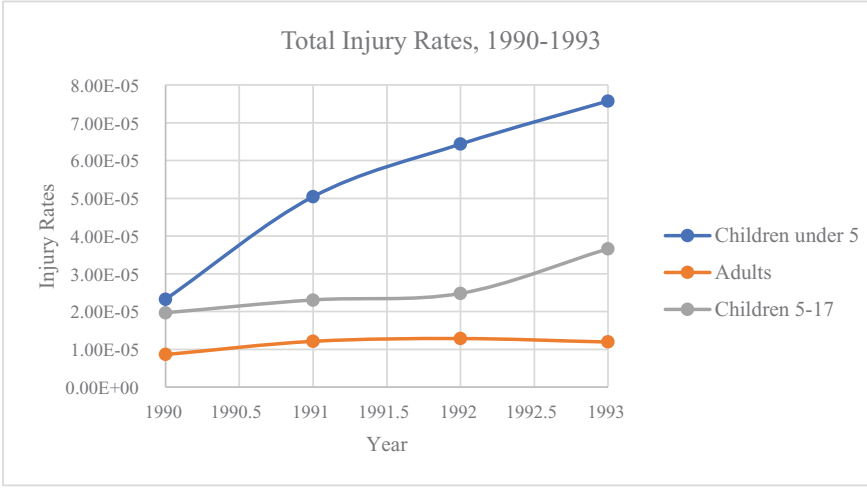

Figure 4. *Pre-regulation lighter injury rate trends by age group.*

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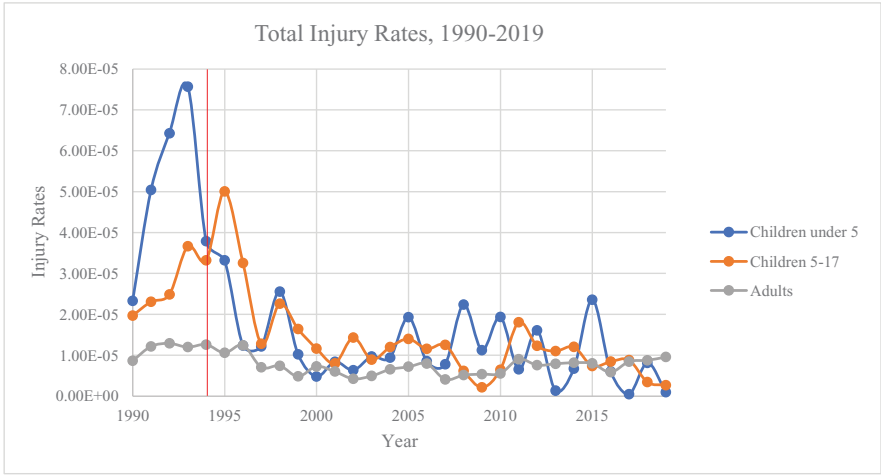

Figure 5. *Lighter injury rate trends by age group.*

For both groups of children, injury rates were actually increasing. Figure 5 shows total injury rates for the full time period, illustrating the drop in injury rates post-regulation.

Our main empirical model is as follows:

$$c_t = \alpha + \beta CPSC_t + \theta A_t + \gamma CPSC_t \times A_t + \gamma_t + \varepsilon_t, \quad (1)$$

where c_t is the rate of injuries in a year, $CPSC_t$ is a dummy variable for the presence of the CPSC cigarette lighter regulation (coded as 0 pre-1994, 0.5 in 1994, and 1 post-1994), A_t is a dummy variable for whether the injury rate is the younger age in the comparison (either children under 5 or children ages 5–17), γ_t are year fixed effects, and ε_t is the error term. The comparison groups will capture the influence of trends in lighter usage, such as those relating to smoking behavior, which will affect adults directly and children indirectly. The comparison groups used will be:

(i) children under 5 versus adults;
(ii) children under 5 versus children ages 5–17; and
(iii) children ages 5–17 versus adults.

3.3 Regression estimates

Table 2 reports the regression estimates of the difference-in-differences model in Equation (1) for the four different injury rate measures for children under 5 compared to adults, followed by a similar analysis using those age 5–17 as the reference group. Table 2 also includes estimates of the impact of the regulation on the age 5–17 group compared to adults. In addition to the variables for which estimates are reported in Table 2, the equation also includes a CPSC dummy variable for the post-regulation period as well as fixed effects by year. For the first two columns, the younger age group consists of those under 5, while for the final column the younger age group is the 5–17 year age group. The overall effect of the younger age group variable apart from the interaction with the post-regulation time period is to have a significantly higher overall injury rate and burn rate. These overall differences are

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Table 2. *Cigarette safety regulation on cigarette lighter injuries in children.*

Variables	(1) Children under 5 versus adults	(2) Children under 5 versus age 5–17	(3) Children age 5–17 versus adults
Total injuries			
CPSC regulation ×	−3.78***	−2.80***	−0.98**
Younger age	(0.54)	(0.54)	(0.48)
Younger age	4.23***	2.64***	1.59***
	(0.50)	(0.50)	(0.44)
R-squared	0.87	0.89	0.75
Percent decrease	71%	52%	38%
Burn injuries			
CPSC regulation ×	−2.99***	−2.02***	−0.98**
Younger age	(0.39)	(0.35)	(0.39)
Younger age	3.26***	1.68***	1.59***
	(0.36)	(0.32)	(0.36)
R-squared	0.88	0.92	0.76
Percent decrease	74%	50%	43%
Total admitted injuries			
CPSC regulation ×	−0.35***	−0.24**	−0.11
Younger age	(0.09)	(0.11)	(0.09)
Younger age	0.34***	0.12	0.21**
	(0.09)	(0.10)	(0.08)
R-squared	0.63	0.66	0.59
Percent decrease	85%	59%	39%
Admitted burn injuries			
CPSC regulation ×	−0.33***	−0.29***	−0.04
Younger age	(0.09)	(0.10)	(0.08)
Younger age	0.33***	0.18*	0.16*
	(0.08)	(0.09)	(0.08)
R-squared	0.63	0.69	0.60
Percent decrease	84%	74%	20%
Observations	60	60	60

Note: Columns (1)–(3) include year fixed effects.
***$p < 0.01$;
**$p < 0.05$;
*$p < 0.1$.

not statistically significant for the comparison with the hospitalized cases for 5–17-year-olds, which are relatively low.

The main result of interest is the interaction between the CPSC regulation variable and the younger age group, which is ages 0–4 for columns 1 and 2, and ages 5–17 for column 3. The primary focus is on the comparisons with the trajectory for adults, which appear in

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columns 1 and 3. Using adult rates as the reference point trajectory, the regulation reduced all lighter-related injury rates by 71%, burn injury rates by 74%, total injuries leading to hospital admission by 85%, and total burn injuries leading to hospital admission by 84%. These impacts of the regulation on the risk levels for the target age group are in line with or exceed the prediction by the CPSC that "the rule could eventually reduce child-play fire losses by up to (85–50/50) = 70%" 58 FR 37564. The risk reductions using the 5–17 age group as the reference point follow a similar pattern but involve less of a percentage risk reduction induced by the regulation since the injury rates for the 5–17 age group were also influenced by the lighter safety standard. Consequently, they do not serve as an ideal reference point for the injury rate trajectory for children under the age of 5 that would have been observed in the absence of the standard.

The regression results for the impacts on the 5–17-year-old age group indicate that the lighter safety standard reduced the injury rates for this group as well, as shown in the final column of Table 2. The decrease in injury rates for 5–17-year-olds was 38% for total injuries and 43% for total burn injuries. The sample size for the lighter-related hospitalizations for the 5–17-year-old age group is very small, and the regulatory policy variable impacts on hospitalizations are not statistically significant for this group. Although the lighter safety standard was targeted at child play with lighters by those under age 5, the regulation had substantial risk-reducing effects on injuries not requiring hospitalization for those in the age 5–17 group.

4. The monetized value of injury reductions

The total injuries prevented by the regulation rather than the injury rate is pertinent to the benefit assessment. The baseline numbers of injuries that could be reduced by the CPSC regulation are presented in Table 3, which presents the average total number of injuries in the 1990–1993 period for the children under 5 group and those ages 5–17. Although the injury rates are greater for the youngest age group, the age 5–17 group has a larger population and a higher total number of injuries. The CPSC also estimates that there were 150 deaths annually due to lighters, most of which were to the under 5 age group.

Table 4 presents the estimates of the total risk reductions by applying the percentage impact statistics from Table 2 to the baseline injury numbers in Table 3. The percent decrease statistics used to calculate the injury reductions and the injury reduction amounts appear for the under 5 age group in the first column of Panel A and in Panel B for the 5–17 group. Here we report only the estimates using the trend for the adult population as the reference group. Because of the greater percentage risk reduction impacts for the youngest age group, the injury reductions for this group are greater than for the age 5–17 group. The injury categories

Table 3. *Average annual pre-regulation injuries.*

Injury numbers pre-1994	Children under 5	Age 5–17
Total injuries	1039.0	1219.7
Burn injuries	784.8	1071.20
Total admitted injuries	80.1	128.2
Admitted burn injuries	75.8	91.6

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Table 4. *Post-regulation injury decrease.*

Children under 5 injury reduction from pre-1994 levels	Estimated percent decrease	Injury decrease
Total injuries	71	737.7
Burn injuries	74	580.7
Total admitted injuries	85	68.1
Admitted burn injuries	84	63.7
Deaths (using CPSC numbers) – avg. 150	71–85	106.5–127.5
Children age 5–17 injury reduction from pre-1994 levels	**Estimated percent decrease**	**Injury decrease**
Total injuries	38	463.5
Burn injuries	43	460.6
Total admitted injuries	39	50.0
Admitted burn injuries	20	18.3

Note: Adults are the comparison in both Panels A and B.

are overlapping because burn injuries and admitted injuries are components of total injuries. To assess the overall risk reduction impacts, it is appropriate to either consider rows 1 and 5 focusing on total injuries and deaths, or restrict the assessment to rows 2 and 5, focusing only on burn injuries and deaths. For purposes of monetizing benefits, we focus only on injury totals and deaths without assigning separate values to the admitted injury group.

To monetize the benefits, we use estimates for the value of risk reductions converted to 1993 prices, which was the year of the CPSC regulatory impact analysis. The largest benefit component is the mortality risk reduction for which the CPSC used a value of $2 million. The VSL estimate that we use is greater than the amount used by CPSC and is based on the $10 million ($ 2015) figure reported in Viscusi (2018), which was derived from the bias-adjusted labor market estimates using the Census of Fatal Occupational Injuries data. This value converts to $6 million in 1993 dollars. Smith *et al.* (2002) valued each expected death at $5 million based on Viscusi (1993). The monetized value of mortality risk reductions is consequently based on VSL estimates for adult workers. Stated preference studies such as Hammitt and Haninger (2010), Blomquist *et al.* (2011), Williams (2013), Hammitt and Herrera (2018), and Robinson *et al.* (2019) revealed preference studies of the value of organic baby food (Maguire *et al.,* 2004) and car seats (Byl, 2013) have suggested that mortality risks to children may receive a premium of 50–270%. While USA agencies do not use a child premium in their quantifiable benefits, an "unquantifiable" child premium was part of the justification for NHTSA's recent rearview camera regulation for which the quantifiable costs without a premium exceeded quantifiable benefits.[7] 79 Fed. Reg. 19,178 2014, p. 19,236. Thus, our estimates may provide an underestimate of the mortality risk reduction benefits.

[7] "While the agency has used the Department's standard monetary figure for the value of a statistical life, we acknowledge that various studies have placed the value of a statistical life at a higher value and the value of a statistical life of a child even higher" (79 Fed. Reg. 19,178 2014, p. 19,236).

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For the procedure used to calculate the unit value of nonfatal injuries, we assumed that they were comparable to the implicit value of the risk of nonfatal job injuries. The estimate found by Viscusi and Gentry (2015) is $55,000 after being converted to 1993 dollars. This unit benefit figure is very similar to the $50,000 figure for the societal cost of cigarette fires from Miller (1993), which was used in the benefits assessment by Smith *et al.* (2002).

Table 5 presents the injury reduction counts for children under 5 in column 1, the injury reductions for children age 5–17 in column 2, and the sum of these values in column 3, the unit value applied to these injuries in column 4, and the total benefit valuation in column 5. Because of the overlapping nature of the categories, we present two different measures of the benefits. The first measure consists of the risk reductions based on the overall number of injuries, that is, rows 1 and 5. The total monetized value of these benefits is at least $939,778,500 for all injuries and deaths. The second, somewhat smaller measure consists of the reduced number of burn injuries plus reductions in deaths, as shown in rows 2 and 5, for which we use the overall death value in the absence of a burn-specific estimate. The burn-related value of risk reductions is at least $931,787,500. In each case, the annual benefits of the regulation greatly exceed the projected annual costs of $90 million. Death decrease ranges were estimated by applying the range of percent decreases from the different injury types.[8] Initial death levels for children age 5–17 were estimated assuming that their ratio of injuries to deaths was the same as that for children under age 5.[9] The reduction in property damage as a result of the regulation would be in addition to the injury reduction amounts. If the 71% overall injury reduction estimate for children under 5 is pertinent in assessing the reduced property damage, the property damage reduction benefit is in line with CPSC's estimate based on a 70% reduction. However, there is also an additional property damage reduction from decreased fires for the 5–17 age group, which would boost the property damage reduction by 63%.

5. Conclusion

Disposable cigarette lighter safety regulations have been remarkably effective in reducing the risks to the target high risk group of children under 5. An additional dividend is that the regulation also has reduced risks among older children, but not to the same extent. Not only did the regulation generate the expected benefits among the target population group, but it has broader, beneficial safety impacts as well, with a total annual health benefit of $939,778,500–$1,464,688,500.

The success of the regulation was not guaranteed. Safety devices for cigarette lighters are not structured in a manner designed to completely eliminate the hazard or to make lighters "childproof," despite frequent claims of a childproof attribute. Up to 15% of children under 5 who are tested can operate a lighter with an approved lighter safety mechanism. Surveys of parental concern with lighters indicate that the presence of safety devices induces parents to be lulled into a false sense of security, leading them to be less concerned about safety and

[8] For example, the different categories for children under 5 (all injuries total, total admitted injuries, burn injuries total, and admitted burn injuries) each decreased between 71 and 85 %. We estimated how much deaths would decrease if they decreased 71 % and how much they would decrease if they decreased 85 % to create the range.

[9] The ratio of all injuries for children under 5 to all injuries for then 5–17 age group was about 2.05. The ratio of total admitted injuries was about 1.46, and the ratios for burn injuries and admitted burn injuries were between those two numbers. We estimated initial deaths for age 5–17 using this range.

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Table 5. *Annual injury reduction valuations.*

Injury type decrease	Children under 5	Children age 5–17	Total injury counts	Valuation of injury type	Total benefit valuation
All injuries total	737.68	463.49	1201.17	$50,000	$60,058,500
Burn injuries	580.74	460.61	1041.35	$50,000	$52,067,500
Total admitted injuries	68.05	50.01	118.06	$50,000	$5,903,000
Admitted burn injuries	63.7	18.32	82.02	$50,000	$4,101,000
Deaths (using CPSC numbers) – avg. 150	106.50–127.50	40.12–86.25	146.62–213.75	$6,000,000	$879,720,000–$1,282,500,000
Total					$939,778,500–$1,464,688,500
Total burn-related					$931,787,500–$1,334567500

children's access to lighters. Nevertheless, the efficacy of the safety mechanism is sufficiently great that the regulation has produced a substantial risk reduction.

The observed safety benefits of the regulation are in line with the CPSC's *ex ante* estimates for the under 5 age group. However, the risk reductions for older children increase the estimated impacts of the regulation. The safety benefits for older children boost the total number of burn injuries reduced by the regulation by 63% of the value of the injury reductions for the target regulatory age group of children under 5. Based on society-wide values for the VSL and the counterpart value of statistical injuries, the regulation's performance easily passes a benefit–cost test. If a premium is assigned to the valuation of risks to children, as some studies suggest, then the attractiveness of the child-resistant lighter regulation is even greater.

Competing Interests. In 1990, W.K.V. collaborated on a pilot study for BIC that analyzed household responses to cigarette lighter safety devices. R.D. has no conflicts of interest to report.

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