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Permalink

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Journal

Otolaryngology--head and neck surgery : official journal of American Academy of Otolaryngology-Head and Neck Surgery, 148(6)

ISSN

0194-5998

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Publication Date

2013-06-01

DOI

10.1177/0194599813482293

Peer reviewed

Systematic Assessment of Noise Amplitude Generated by Toys Intended for Young Children

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Otolaryngology—
Head and Neck Surgery
148(6) 1043–1047
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Otolaryngology—Head and Neck
Surgery Foundation 2013
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DOI: 10.1177/0194599813482293
http://otojournal.org

No sponsorships or competing interests have been disclosed for this article.

Abstract

Objective. To systematically evaluate the noise generated by toys targeted for children and to compare the results over the course of 4 consecutive holiday shopping seasons.

Study Design. Experimental study.

Setting. Academic medical center.

Subjects and Methods. During 2008–2011, more than 200 toys marketed for children older than 6 months were screened for loudness. The toys with sound output of more than 80 dBA at speaker level were retested in a soundproof audiometry booth. The generated sound amplitude of each toy was measured at speaker level and at 30 cm away from the speaker.

Results. Ninety different toys were analyzed. The mean (SD) noise amplitude was 100 (8) dBA (range, 80–121 dBA) at the speaker level and 80 (11) dBA (range, 60–109 dBA) at 30 cm away from the speaker. Eighty-eight (98%) had more than an 85-dBA noise amplitude at speaker level, whereas 19 (26%) had more than an 85-dBA noise amplitude at a 30-cm distance. Only the mean noise amplitude at 30 cm significantly declined during the studied period ($P < .001$). There was no significant difference in mean noise amplitude of different toys specified for different age groups.

Conclusion. Our findings demonstrate the persistence of extremely loud toys marketed for very young children. Acoustic trauma from toys remains a potential risk factor for noise-induced hearing loss in this age group, warranting promotion of public awareness and regulatory considerations for manufacture and marketing of toys.

Keywords

acoustic trauma, noise-induced hearing loss, pediatric noise exposure, toys, sensorineural hearing loss

Received December 6, 2012; revised January 31, 2013; accepted February 21, 2013.

Noise-induced hearing loss (NIHL) has emerged as the second most common cause of sensorineural deficit after presbycusis.¹ Although most of the regulatory focus for NIHL has been on occupational noise, recreational noise exposure has demonstrated an increasing contribution to NIHL in all age groups in recent decades.^{2–4} A common source of exposure to recreational noise during infancy and early childhood is through playing with toys. Previous studies have found that permanent hearing threshold shifts could occur in association with noisy toys, games, and firecrackers.^{3,5–10} Acoustic properties of the ear canal in infants and young children may make them susceptible to high-frequency noise trauma.¹¹ Animal studies have discovered a period of noise susceptibility that exists shortly after birth.¹² This susceptibility, in addition to regular interaction with toys, warrants further investigation of the produced noise levels of commercially available toys intended for young children.

The devices with impulsive high-level sounds pose the greatest risk for significant permanent hearing loss and tinnitus after single exposure.^{12,13} These loud sounds are also capable of producing nonauditory effects such as increased heart rate, loss of sleep, and elevated blood pressure, as well as alterations in central nervous system (CNS) signaling.¹⁴ Although the National Institute for Occupational Safety and Health (NIOSH, part of the Centers for Disease Control and Prevention) has been regulating the exposure time to occupational noise (**Table 1**), regulations for toys were not

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This article was presented as a poster at the 2012 AAO-HNSF Annual Meeting & OTO EXPO; September 9–12, 2012; Washington, DC.

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Table 1. National Institute for Occupational Safety and Health recommended exposure limit.

Duration per Day	Sound Level, dBA
8 h	85
4 h	88
2 h	91
1 h	94
30 min	97
15 min	100
7.5 min	103
<4 min	106
<2 min	109
<1 min	112

much organized until 2003, when the American Society for Testing and Materials (ASTM) voluntary toy noise standards were finalized. The most recent standards recommend that the toys designed to emit sound should produce less than 85 dBA noise at 50 cm away from the microphone (previously, 90 dBA at 25 cm). For the toys classified as “close-to-the-ear,” a maximum of 65 dBA measured from 2.5 cm is required.¹⁵

In the recent literature, only 2 studies have sought to systematically assess the noise levels of commercially available toys in the United States,^{16,17} and only one of them has addressed this issue since the publication of the ASTM voluntary toy noise standards. In the present study, we aimed to systematically measure the noise levels of the toys introduced during 4 consecutive years from 2008 to 2011.

Methods

Multiple national department stores (including Target, Toys“R”Us, and Walmart) were inspected for 4 consecutive years during the months of November to January beginning in 2008 and ending in 2011. All toys that were labeled for children ages 6 months to 5 years and up were screened by 2 of the investigators. Those with continuous or fluctuating electronic sounds were included in the study. Two-hundred seventy toys met these criteria. In-store preliminary screening was performed on these toys using a portable sound-level meter (SPL Meter; Studio Six Digital, <http://www.studiosixdigital.com/>). Those with peak sound output of more than 80 dBA at speaker level were selected for further evaluation. The selected toys were retested in a double-walled anechoic chamber at our institution. Measurements of sound intensity were performed using a portable digital sound meter (Sound Level Meter 2238 Mediator; Brüel & Kjær, Naerum, Denmark). The meter was programmed to record the greatest amplitude of sound, expressed in dBA, at all frequencies created by the toy. The position of the microphone in relation to the toy’s speaker was standardized at a distance of 0 cm and 30 cm for each recording

Figure 1. Noise measurement at the speaker level using the sound level meter.

(**Figure 1**). All of the toys were operated to produce the maximum sound output for approximately 20 seconds.

Statistical Analysis

The mean, standard deviation (SD), and range of values were calculated for noise amplitude at a 0- and 30-cm distance and reported, as well as the number of toys generating a noise level of 85 dBA or more. One-way analysis of variance (ANOVA) was used to compare the results among different years of production and age specification groups. The noise amplitude was not measured at 30 cm in the first year of the study (2008). All statistical procedures were performed using PASW 18.0 (SPSS, Inc, an IBM Company, Chicago, Illinois). A *P* value of less than .05 was considered statistically significant.

Results

A total of 90 different toys had a peak sound output of more than 80 dBA at speaker level during the in-store preliminary testing and were selected for further evaluation. Mean (SD) noise amplitude peak was 100 (8) dBA at the speaker level or 0 cm (range, 80-121 dBA) and 80 (11) dBA at 30 cm away from the speaker (range, 60-109 dBA). **Tables 2 and 3** present the measurements in detail, stratified based on year of production and age group specifications. Eighty-eight toys (98%) had more than an 85-dBA noise amplitude at speaker

Table 2. Noise amplitude measurements at speaker level and 30-cm distance categorized by year of toy production.

Year	No. of Toys Tested	At Speaker Level, dBA			At 30-cm Distance, dBA		
		No. (%) of Toys ≥ 85 dBA	Mean $\pm$ SD	Range	No. (%) of Toys ≥ 85 dBA	Mean $\pm$ SD	Range
2008 ^a	17	16 (94)	96 $\pm$ 7	80-106	NA	NA	NA
2009	18	17 (94)	103 $\pm$ 9	83-121	14 (78)	93 $\pm$ 9	79-109
2010	45	45 (100)	100 $\pm$ 8	85-117	5 (11)	77 $\pm$ 7	65-100
2011	10	10 (100)	97 $\pm$ 5	92-108	0	67 $\pm$ 4	60-74

Abbreviation: NA, not available.

^aIn 2008, only the noise amplitude at speaker level was evaluated.**Table 3.** Noise amplitude measurements at speaker level and 30-cm distance categorized by advertised age group.

Marketed for Age Group	No. of Toys Tested	At Speaker Level, dBA			At 30-cm Distance, dBA		
		No. (%) of Toys ≥ 85 dBA	Mean $\pm$ SD	Range	No. (%) of Toys ≥ 85 dBA	Mean $\pm$ SD	Range
Younger than 3 years	38	36 (95)	99 $\pm$ 9	80-117	8 (26)	81 $\pm$ 10	67-100
Older than 3 years	34	34 (100)	99 $\pm$ 8	85-121	6 (21)	78 $\pm$ 11	65-109
Older than 5 years	18	18 (100)	101 $\pm$ 7	90-115	5 (36)	81 $\pm$ 14	60-106

In 2008, data at 30 cm were not collected for the following age groups: younger than 3 years ($n = 7$), older than 3 years ($n = 6$), and older than 5 years ($n = 4$).**Table 4.** Top noise-generating toys sorted by descending peak noise amplitude at speaker level.

Name	Measurement Year	Noise Amplitude at Speaker Level, dBA	Noise Amplitude at 30-cm Distance, dBA
Mattel The Secret Saturdays Fire Sword	2009	121	109
Little Tikes Jungle Jamboree 2-in-1 Piano/Xylophone	2010	117	100
Zillionz Deluxe ATM Savings Bank	2009	115	106
Transformers Optimus Prime Voice Changer	2010	114	85
Little Tikes Tap-A-Tune Piano	2010	112	97
Step 2 Basic Rhythms Xylophone	2010	112	87
Fisher Price Musical Ocean Friends Table	2010	112	77

level—the maximum level for continuous noise exposure in an 8-hour period is 85 dBA, as recommended by NIOSH—whereas 19 (26%) had more than an 85-dBA noise amplitude at a 30-cm distance. **Table 4** lists the toys that generated a sound level of 112 dBA or more.

One-way ANOVA test revealed that the mean noise amplitude at speaker level was not different between study years ($F(3, 86) = 2.681$, $P = .052$) or age groups ($F(2, 87) = 0.558$, $P = .574$). The data points for noise amplitude at a 30-cm distance were not normally distributed. Therefore, the Kruskal-Wallis test (nonparametric equivalent of the one-way ANOVA test) was used, which revealed that the mean noise amplitude at a 30-cm distance declined significantly from 2009 to 2011 (median dB was 95, 76, and 68.5 for ascending years, respectively; $H(2) = 40.03$, $P < .001$). Such a difference between age groups was not significant

(median dB was 80, 75, and 79.5 for ascending age groups, respectively; $H(2) = 1.774$, $P = .412$).

Discussion

Our study demonstrated the persistence of extremely loud toys marketed for very young children on the market in recent years. Although we noted a statistically significant decline in mean amplitude of noise generated by the loudest toys at 30 cm over the study period, the measured amplitude at the speaker level did not change significantly over the same period. These results are consistent with a previous analysis of commercially available toys showing persistence of noise exceeding 110 dB at speaker level and 100 dB at arm's length (25-30 cm).¹⁶ There is no clear indication, in the present study, that there has been a concerted effort on the part of the

industry to limit the amplitude of noise generated by toys since the 1997 study by Yaremchuk et al.¹⁶

In 2001, Niskar et al.¹⁸ estimated the prevalence of NIHL among children 6 to 19 years of age in the United States to be approximately 5.2 million. This study was criticized because it failed to require noise exposure history for the diagnosis of NIHL.¹⁹ This criticism, however, does not take into account the pervasive exposure of the pediatric age group to unregulated noise generated by toys, games, and music players, as evidenced by studies such as the present one. If similar numbers for the incidence of NIHL are replicated in future epidemiologic studies of this age group, pediatric recreational NIHL must be considered a serious public health issue that deserves the same level of scrutiny as occupational NIHL in adults. A first step toward addressing this issue would be to address the efficacy of current regulations governing the manufacture and marketing of noise-generating devices targeting the pediatric population.

Despite the evidence for NIHL in the pediatric age group, there are no federal regulations in the United States that limit the noise levels of toys. The ASTM standards represent industry self-regulation, harboring numerous exceptions and voluntary compliance. The 2004 ASTM guidelines state that a handheld, table-top, or crib toy should not exceed 90 dB at 25 cm. In 2009 and 2010, 19 toys identified in our study exceeded 85 dBA at 30 cm. Although our study indicates that in 2011, all the toys tested complied with the industry standards, the overall compliance record has been less than perfect, as demonstrated by our study as well as previous reports.^{17,20}

Although we sought to investigate a representative sample of children's toys in the present study, our data are not a comprehensive analysis of the entire market. A more comprehensive study might only lead to identification of a larger number of loud toys, which would increase the mean amplitudes determined in our study. In addition, our data did not include many of the other sources of acoustic trauma that children are exposed to at increasingly younger ages such as MP3 players, portable multimedia gadgets, television sets, and video game consoles, among other devices. Those devices are more likely to lead to extended noise exposure periods, which would proportionally increase the risk of NIHL. Epidemiologic studies that establish associations between exposure to loud toys and future risk of NIHL are warranted to further enhance the argument for greater regulatory oversight of the children's toy market.

Conclusion

Our findings demonstrate the persistence of extremely loud toys marketed for very young children. Noise levels for some toys exceeded even the toy manufacturing industry's standards. Acoustic trauma from toys remains a potential risk factor for noise-induced hearing loss in this age group, warranting regulatory considerations for the manufacture and marketing of toys.

Author Contributions

Hossein Mahboubi, design, drafting, final approval; **Sepehr Oliaci**, design, drafting, final approval; **Karam W. Badran**,

design, drafting, final approval; **Kasra Ziai**, design, drafting, final approval; **Janice Chang**, design, drafting, final approval; **Shawn Zardouz**, design, drafting, final approval; **Shawn Shahriari**, design, drafting, final approval; **Hamid R. Djalilian**, design, drafting, final approval.

Disclosures

Competing interests: None.

Sponsorships: None.

Funding source: None.

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