

Noise levels of toys for children between the ages of birth and 3 years in South Africa

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Objectives. To describe the noise levels of popular hand-held, tabletop, crib and close-to-the-ear toys for children between the ages of birth and 3 years in South Africa.

Design. A quantitative, non-experimental, descriptive research design was employed for this study.

Subjects. Twenty toys, 5 from each of 4 categories, were chosen from a popular toy store in South Africa. The noise levels of these toys were measured using a sound level meter in a quiet room. The frequency spectra of the noise were analysed and compared with current international standards relating to toy safety.

Results. The majority of toys adhere to the current American Society for Testing and Materials (ASTM) International standards for toy noise. Frequency spectra analysis revealed that the loudest continuous noise levels for all toys were recorded at the frequencies that are the most important for hearing speech.

Conclusions. There is a need to develop standards for the maximum sound output of toys, and compulsory introduction of warnings about the noise levels of toys on the packaging and adherence to ASTM International standards for toy manufacturers are recommended.

Noise-induced hearing loss (NIHL) in children is a growing area of concern for audiologists, who have an important role to play in the prevention of hearing loss in children.¹ One aspect of prevention is the education of adults and children about the potentially harmful effects on the auditory system of exposure to loud noise.² NIHL may negatively affect not only a young child's ability to communicate effectively, but also their social, emotional, cognitive and behavioural development and academic achievement.³

The mechanism of NIHL involves damage to the delicate hair cells lining the basilar membrane of the cochlea. Stereocilia, the mechanosensing organelles of these hair cells, are deflected in a shearing motion and transform the mechanical energy of sound waves into electrical impulses for the hair cells. This results in an excitation of the auditory nerve.^{4,5} Excessively loud sounds can damage or destroy the stereocilia. The hearing damage can transpire in two ways. Brief exposure to extremely loud sounds can cause permanent damage, while continuous exposure to loud sounds wears out the hair cells and weakens their ability to recover, resulting in permanent hearing loss.

Sound intensity or loudness, measured as sound pressure level (SPL) in a logarithmic decibel (dB) scale, is used to indicate how we hear a specific sound. The point at which a person starts to hear sound is referred to as a dB of 0, while a whisper is equal to 30 dB. An average rock band performance can measure up to 110 dB and a firecracker up to 145 dB (Table 1).⁶ Continuous exposure to noise of 85 dB or more over a typical 8-hour workday can cause permanent hearing loss.⁵

NIHL as a result of exposure to noise from toys is common among children.⁷ Of children between the ages of 6 and 19 years in the USA, 12.5% have NIHL.⁸ NIHL is more common in boys than in girls

TABLE 1. NOISE LEVEL CHART⁶

Loudness (dB)	Source
0	Softest sound that can be heard
10	Normal breathing
30	Whisper
50 - 65	Normal conversation
80 - 85	City traffic noise
95 - 110	Motorcycle
110	Rock band
120	Thunderclap
125	Balloon popping
145	Firecracker

between the ages of 6 and 19 years, which may be because boys are more likely to play with noisy toys and to be involved in noisy activities.⁹ In Finland and Germany, 8% and 7% respectively of schoolchildren between the ages of 6 and 7 had a hearing loss of 20 dB or more at one frequency or more.¹⁰ Interestingly, toy guns and fireworks were found to be a major cause of hearing loss in children.¹¹ Tympanic membrane perforations were reported in 7 out of 53 children, while 39 out of 53 children were diagnosed with a unilateral hearing loss. Exposure to these toys was further reported to be the cause of bilateral hearing loss in 14 of the 53 children.

The current toy standards from the American Society for Testing and Materials (ASTM) International are based on product standard information that was obtained by the National Bureau of Standards in 1976. These standards are based on the Occupational Safety and Health Administration standards for adult noise exposure in an industrial setting.¹²

The noise standards for children's toys (hand-held, tabletop, floor and crib toys) indicate that a toy should not emit a continuous sound greater than 90 dBSPL when measured from a distance of 25 cm.¹² The standards for close-to-the-ear toys are that they should not produce a sound greater than 70 dBSPL when measured from 2.5 cm¹² and should not produce a sound greater than 90 dBSPL when measured from 25 cm, which is regarded as how close to the ear children are likely to hold these toys.² The International Standards Organization suggests that close-to-the-ear toys should not be louder than 65 dB when measured in free-field conditions, and all other toys should not be louder than 85 dB. The Canadian Association of Speech-Language Pathologists and Audiologists advises that these standards need to be changed, as these levels are not safe enough to protect children's hearing.¹³

Research has found that a number of toys produce sounds that exceed the ASTM International standards.^{7,14} It has been reported that 17 out of 25 toy cell phones and walkie-talkies produced sounds that were either equal to or greater than 115 dBA.¹⁴ Squeaky toys and some rattles have been found to emit sound at a level of 110 dB, while toy guns emit sound at a level of 150 dB. Musical toys have been found to emit sound at a level of 120 dB, and toy telephones at a level of 125 dB.⁷ Other toys that have been found to emit sound levels above 90 dBA include toy trumpets and whistles.¹⁵

There are currently no noise level standards specific to children's toys in South Africa. Describing the noise levels of children's toys is important, as this will enable audiologists to educate health care professionals and caregivers about the effects that exposure to noise from toys may have on children's hearing. The purpose of this study was to determine the noise levels of popular hand-held, tabletop, crib and close-to-the-ear toys for children between the ages of birth and 3 years in South Africa.

Methodology

Aims

The main aim of the study was to measure the noise levels of popular hand-held, tabletop, crib and close-to-the-ear toys for children between the ages of birth and 3 years in South Africa. The sub-aims of the study were:

- to measure the frequency spectra of the noise produced by the children's toys
- to compare the sound pressure level measurements obtained with the ASTM International standards for toy noise.

Research design

A quantitative, non-experimental, descriptive research design was employed to describe the relationship between noise levels of different types of toys measured at different distances, and the relationship between noise and different frequencies.

Materials

A total of 20 toys, 5 from each of the categories of hand-held, tabletop, crib and close-to-the-ear, were donated for testing by a well-known South African toy store. The most popular toys, labelled as appropriate for children aged birth to 3 years, were informally assessed and only included in the study if they created loud or continuous sounds. Seventeen of the toys were manufactured in China and 3 in Hong Kong. All the toys featured choking hazard warnings, but for only 2 (close-to-the-ear toys 3 and 4) was it stated on the packaging that as a safety precaution the sound volume of the telephones would be lower once the toy was removed from the packaging. A description of the toys is presented in Table 2.

Equipment

A recently calibrated Quest Technologies 1900 Precision Integrated/Logging Type I sound level meter with a 1/1 - 1/3 octave filter set was used to collect data. The equipment adhered to current American National Standards Institute (ANSI) standards.

Testing environment and parameters

The sound level meter readings were recorded in a quiet, carpeted room. The environmental noise levels during testing ranged from 20 dBA to 36 dBA. The environmental noise during testing is similar to the World Health Organization guidelines for community noise.¹⁶ The range on the sound level meter was different for each toy, to ensure that the sound produced by the toy was not out of the range of the sound level meter and to ensure accurate results. Sound level meter measurements were A-weighted and set on the fast setting, as per the standards set by the ASTM International standard for measuring toys.

Sound level meter readings were taken at distances of 25 and 2.5 cm from the toy. The toy was set to its highest volume setting if it had varying levels of noise output. The toy and the sound level meter were at least 1 cm away from any walls, floor or ceiling. Toys were placed on hard surfaces if that was how they were meant to be used, for example the tabletop and crib toys.

The sound level output and frequency spectral analysis of the noise from each toy was measured three times, and an average was taken for each.

Ethical approval was obtained from the University of the Witwatersrand's non-medical research ethics committee. Anonymity of the brands and name of toys used in this study was maintained.

Results

The results of the frequency (the pitch of sound) spectra analysis, maximum sound-field and continuous sound measurements of the noise produced by the toys are presented. The ASTM International

TABLE 2. DESCRIPTION OF TOYS

Per category	Hand-held		Tabletop		Crib		Close-to-the-ear	
	Description	Sound	Description	Sound	Description	Sound	Description	Sound
Toy 1	Ball with movable sections	Clucking	Bus with movable wheels	Songs	Mobile	Music	Cellular phone	Music
Toy 2	Camera	Clicking	Musical television	Music	Play gym	Music	Guitar with headphones	Music
Toy 3	Rattle	Clunking	Musical train	Music	Arch attached to pram	Music	Cellular phone	Dialling tone & ringing
Toy 4	Radio	Songs	Laptop	Animal, transport sounds	Toy with switch	Classical music	Cellular phone	Animal sounds & music
Toy 5	Musical toy	Music	Keyboard with various buttons	Music	Play gym with rattles	Clunking	Rattle	Clunking

TABLE 3. SUMMARY OF RESULTS

Toy category	Distance	Continuous sound level measurements (in dBA) per frequency									
		125 Hz	250 Hz	500 Hz	1 000 Hz	2 000 Hz	4 000 Hz	8 000 Hz	16 000 Hz		
Handheld toys	Range	35.97 - 48.87	50 - 59	59.77 - 76.20	64.40 - 84.07	76.13 - 81.97	66.80 - 86.17	47.77 - 83.37	33.50 - 74.87		
	Average	41.87	53.45	64.84	73.05	79.39	76.65	69.24	56.59		
	SD	5.68	3.39	7.04	7.27	2.18	7.91	14.24	20.62		
25 cm	Range	25.67 - 41.60	32.57 - 51.47	49.60 - 68.47	59.40 - 69.77	64.10 - 73.23	43.40 - 76.13	38.07 - 76.97	21.70 - 69.20		
	Average	32.47	42.81	57.70	63.15	68.68	64.10	56.79	47.33		
	SD	5.68	6.78	7.20	4.31	4.37	14.06	19.02	23.60		
Tabletop toys	Range	32.50 - 46.87	41.80 - 61.70	53.20 - 80.07	70.53 - 78.73	69.93 - 79.97	60.67 - 77.90	50.80 - 69	37.23 - 55.67		
	Average	37.75	50.83	70.43	76.89	75.59	67.43	60.41	46.77		
	SD	6.25	8.02	11.25	3.57	4.53	7.24	7.35	7.73		
25 cm	Range	22.43 - 41.70	32.13 - 52.27	41.10 - 72.47	58.37 - 74.43	61.03 - 63.17	49.10 - 66.70	35.50 - 58.57	20.30 - 48.47		
	Average	27.89	42.08	59.79	65.39	62.20	56.67	50.21	38.49		
	SD	7.96	7.17	12.23	5.81	0.99	8.66	9.30	10.66		
Crib toys	Range	26.53 - 42.83	31.83 - 64.43	50.80 - 86.67	54.17 - 83.33	50.60 - 76	52.50 - 75.27	34.27 - 85.17	11.60 - 77.07		
	Average	34.50	43.43	63.08	69.06	66.11	63.69	54.39	42.87		
	SD	7.48	13.02	14.80	12.73	10.34	10.21	18.94	23.22		
25 cm	Range	24.83 - 34.83	27.17 - 52.53	40.40 - 73.70	39.73 - 69.43	37.13 - 61.40	38.43 - 70.50	21 - 81.17	11.60 - 71.37		
	Average	28.39	35.69	51.03	55.83	53.65	53.37	45.75	36.66		
	SD	4.22	11.17	14.08	11.85	9.90	14.43	22.16	21.89		
Close-to- the-ear toys	Range	3.77 - 38.33	28.20 - 43.27	47.50 - 59.87	53.80 - 71.07*	45.97 - 74.47*	53.20 - 67.83	36.73 - 77.77*	16.53 - 72.70*		
	Average	28.21	36.53	53.38	59.42	56.71	57.30	47.91	33.23		
	SD	6.38	6.28	5.64	6.91	11.03	6.07	16.84	22.76		
25 cm	Range	23.77 - 31.20	27.50 - 41.93	40.17 - 70	45.93 - 70.43	37.03 - 60.60	37.27 - 61.67	27.47 - 72.90	11.93 - 67.67		
	Average	26.10	33.15	51.03	54.17	46.99	48.03	41.31	29.19		
	SD	3.25	5.72	11.42	9.43	9.56	10.14	18.76	23.93		

*Exceeded ASTM International limit of 70 dBA.
Hz = Hertz (unit of measure for frequency); SD = standard deviation.

standards state that hand-held, tabletop and crib toys should not exceed 90 dBA when measured from a distance of 2.5 cm and 25 cm. Close-to-the-ear toys should not exceed 70 dBA when measured from a distance of 2.5 cm and 90 dBA for a distance of 25 cm. A summary of the results of the continuous noise measured per frequency is presented in Table 3.

Hand-held toys

Frequency spectra analysis

- The greatest amount of continuous acoustic energy was recorded between 500 Hz and 16 000 Hz for the hand-held group of toys.
- Maximum sound-field measurements were also recorded for each of the toys despite the fact that current toy noise standards are based on continuous noise and not the maximum output of the toy. The maximum sound recorded for the hand-held toys ranged from 36.23 dBA to 92.97 dBA when measured from a distance of 2.5 cm. The maximum sound recorded for the hand-held toys when measured from a distance of 25 cm ranged from 24.50 dBA to 81.83 dBA.
- Continuous sound for the hand-held toys ranged from 33.50 dBA to 86.17 dBA when measured from a distance of 2.5 cm. When measured from a distance of 25 cm, the continuous sound ranged from 21.70 dBA to 76.97 dBA. None of these toys exceeded the ASTM International 90 dBA limit.

Tabletop toys

Frequency spectra analysis

- The greatest amount of continuous acoustic energy was recorded between 500 Hz and 4 000 Hz for the tabletop group of toys.
- The maximum sound-field measurements recorded ranged from 41.47 dBA to 89.60 dBA when measured from a distance of 2.5 cm. Measurements taken at a distance of 25 cm ranged from 24.83 dBA to 78.47 dBA.
- The continuous sound for the tabletop toys ranged from 32.50 dBA to 80.07 dBA when measured from a distance of 2.5 cm, and from 20.30 dBA to 74.43 dBA when measured from a distance of 25 cm. None of the tabletop toys exceeded the ASTM International 90 dBA limit.

Crib toys

Frequency spectra analysis

- The greatest amount of continuous acoustic energy was recorded between 500 Hz and 4 000 Hz for the crib group of toys.
- The maximum sound-field measurements recorded for the crib toys when measured from a distance of 2.5 cm ranged from 11.73 dBA to 89.73 dBA, while at 25 cm the measurements ranged from 11.60 dBA to 84.83 dBA.
- The crib toys' continuous sound ranged from 11.60 dBA to 86.67 dBA when measured from a distance of 2.5 cm, and from 11.60 dBA to 73.70 dBA when measured from 25 cm. None of the crib toys exceeded the ASTM International 90 dBA limit.

Close-to-the-ear toys

Frequency spectra analysis

- The greatest amount of continuous acoustic energy was recorded between 500 Hz and 4 000 Hz for the close-to-the-ear group of toys.
- These toys' maximum sound recorded ranged from 22.17 dBA to 82.30 dBA when measured from a distance of 2.5 cm, while measurements recorded at a distance of 25 cm ranged from 15.23 dBA to 76.30 dBA.
- When measured from a distance of 2.5 cm, the continuous sound for the close-to-the-ear toys ranged from 16.53 dBA to 77.77 dBA. None of these toys exceeded the ASTM International 90 dBA limit when measured from 25 cm. When measured at a distance of 2.5 cm, the continuous sound for the close-to-the-ear toys ranged from 11.93 dBA to 72.90 dBA. Two of these toys exceeded the ASTM international 70 dBA limit for continuous sound.

- The two close-to-the-ear toys that exceeded the recommended toy noise standards were a guitar with earphones and a rattle. The sound output of the guitar was measured through the earphones while on the loudest setting. The loudest continuous sound output for this toy was 72.90 dBA, which occurred at 8 000 Hz. The loudest maximum sound output when measured from the same distance was 76.30 dBA at 1 000 Hz.
- The loudest continuous sound output for the rattle was 70.43 dBA, which was recorded at 1 000 Hz. The loudest maximum sound output was 74.87 dBA at 8 000 Hz. Both of these toys may put children between the ages of birth to 3 years at risk for developing an NIHL.

Discussion

The findings of frequency spectra analysis from this study suggest that the majority of toys measured produced the largest amount of continuous noise outside of the natural frequency range for young children. The natural frequencies for children younger than 2 years of age are between 6 000 and 8 000 Hz, which means that the sound pressure levels of toys are the most acute in this frequency range.¹⁴ This suggests that the toys measured in this study do not place children between the ages of birth and 3 years at high risk of developing an NIHL.

For all four groups of toys, the greatest amount of continuous acoustic energy was recorded between 500 Hz and 4 000 Hz, with 8 000 Hz and 16 000 Hz also included for the hand-held group of toys. These results indicate that the greatest amount of acoustic energy was emitted by all of the toys at the frequencies that are important for hearing speech. The most important frequencies for hearing speech are 500 Hz, 1 000 Hz and 2 000 Hz.¹⁷

Only two of the toys measured exceeded the recommended standard of 70 dBA (for close-to-the-ear toys) for continuous noise, which occurred at 1 000 Hz and 8 000 Hz. These toys were a guitar with headphones and a rattle.

The results of this study suggest that the majority of the toys for children between the ages of birth and 3 years measured in this study adhere to the current ASTM International standards for toy noise. Only 2 out of the 20 toys investigated exceeded the recommended standards. This is in contrast to research conducted in the USA, where it was found that 13 out of 20 toys in the hand-held, tabletop and crib groups exceeded the 90 dBA limit for continuous sound, and all 4 toys in the close-to-the-ear group exceeded the 70 dBA limit for continuous sound.¹² The study, however, did not measure the sound output of toys within a specific age range, and included toy guns. In another study, the sound levels of toy weapons, toy appliances, musical toys, bicycle horns and whistles for children between the ages of 6 months and 6 years were measured.¹⁴ Sound levels of between 80 to 126 dBA were recorded for these toys.

The ASTM International standards are the same for hand-held, tabletop, and crib toys when measured at a distance of 2.5 cm and

Toy manufacturing companies should be encouraged to place warnings about noise levels of toys on the packaging.



25 cm. It is argued that this standard needs to be lowered for sound output at a distance of 2.5 cm, as most of these toys can be placed at ear level. This is important, as children often play with toys closer to their ears than the distances recommended in safety regulations suggest.¹⁸

The ASTM International standards are voluntary for toy manufacturers.¹⁹ Comparing the results of the current study with previous research, it seems likely that toys manufactured in China and Hong Kong for children between the ages of birth and 3 years adhere closely to the current ASTM International standards for continuous noise.¹² However, adhering to toy noise standards needs to become compulsory for toy manufacturers, to reduce the risk of children developing NIHL.

Conclusions

The results of this study indicate that all but 2 of toys for children between the ages of birth and 3 years measured in this study adhere to the current ASTM International standards. Analysis revealed that all the toys emitted the greatest amount of acoustic energy in the frequency range that is the most important for hearing speech. The majority of the toys produced the largest amount of continuous noise outside the natural frequency range for children younger than 2 years of age.

Implications

Although most of the noise levels of the toys included in this research project were not higher than the recommended standards, the public needs to be made aware that children are still at risk for developing NIHL if they play with noisy toys close to their ears and for longer than 1.5 hours a day. Focus needs to be placed on increasing parents' awareness of NIHL in young children.

Practical implications of this research project include creating guidelines for maximum and continuous sound output of toys measured from a distance of 2.5 cm to add to the ASTM International standards. This is important in order to prevent exposure to loud sounds and NIHL in young children. Toy manufacturing companies should be encouraged to place warnings about the noise levels of toys on the packaging. In addition, steps need to be taken to make adherence to ASTM International standards compulsory for all toy manufacturers.

Recommendations for future research

Future research needs to focus on the length of time that children play with noisy toys per day, as well as the distance between the child's ears and the toy during play. It would also be important to investigate the effect of maximum sound output compared with continuous sound output, in order to determine whether standards need to be developed for the maximum sound output of children's toys. Toys that produce explosive and impact noise, such as toy guns, could also be measured and compared with the ASTM International standards.

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