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Hein Raat

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# Adolescents and MP3 Players: Too Many Risks, Too Few Precautions

Ineke Vogel, MSc<sup>a</sup>, Hans Verschuure, PhD<sup>b</sup>, Catharina P. B. van der Ploeg, PhD<sup>c</sup>, Johannes Brug, PhD<sup>a,d</sup>, Hein Raat, MD, PhD<sup>a</sup>

Departments of <sup>a</sup>Public Health and <sup>b</sup>Otolaryngology, Erasmus Medical Center, Rotterdam, Netherlands; <sup>c</sup>Department of Prevention and Healthcare, Quality of Life, Netherlands Organization for Applied Scientific Research, Leiden, Netherlands; <sup>d</sup>Institute for Research in Extramural Medicine, Free University Medical Center, Amsterdam, Netherlands

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## What's Known on This Subject

Prolonged exposure to loud music can induce hearing loss. Adolescents are increasingly exposed to loud music.

## What This Study Adds

When using MP3 players, adolescents are much more likely to engage in risky behaviors than protective behaviors. Frequent use of MP3 players indicates the prevalence of MP3 player-related risky behaviors and the absence of preventive behaviors.

## ABSTRACT

**OBJECTIVE.** The goal was to assess risky and protective listening behaviors of adolescent users of MP3 players and the association of these behaviors with demographic characteristics and frequency of use.

**METHODS.** In 2007, 1687 adolescents (12–19 years of age) in 68 classes in 15 Dutch secondary schools were invited to complete questionnaires about their music-listening behaviors.

**RESULTS.** Ninety percent of participants reported listening to music through earphones on MP3 players; 32.8% were frequent users, 48.0% used high volume settings, and only 6.8% always or nearly always used a noise-limiter. Frequent users were >4 times more likely to listen to high-volume music than were infrequent users, and adolescents in practical prevocational schools were more than twice as likely to listen to high-volume music as were those attending preuniversity education.

**CONCLUSIONS.** When using MP3 players, adolescents are very likely to engage in risky listening behaviors and are unlikely to seek protection. Frequent MP3 player use is an indicator of other risky listening behaviors, such as listening at high volumes and failing to use noise-limiters. *Pediatrics* 2009;123:e953–e958

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### Key Words

adolescents, MP3 player-related behaviors, prevention and control

### Abbreviations

OR—odds ratio

CI—confidence interval

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Address correspondence to Ineke Vogel, MSc, Department of Public Health, Erasmus Medical Center Rotterdam, PO Box 2040, 3000 CA Rotterdam, Netherlands. E-mail: [i.vogel@erasmusmc.nl](mailto:i.vogel@erasmusmc.nl)

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**T**HE HUGE INCREASE in the popularity of portable MP3 players has increased young people's exposure to high sound levels dramatically.<sup>1–3</sup> Various studies reported that increasing numbers of adolescents and young adults now experience symptoms indicative of poor hearing, such as distortion, tinnitus, hyperacusis, or threshold shifts.<sup>4–6</sup> The Hearing Alliance of America reported that levels of hearing loss in 15% of college graduates are now equal to or greater than those of their parents, largely because of listening to music at high volumes.<sup>7</sup> Currently, use of MP3 players may be the most important risk factor for music-induced hearing loss in young people.

The rapid development of digital technology has led to the production of new kinds of portable music players whose sound quality at higher volumes is much better, because the sound is no longer distorted.<sup>3</sup> Because the music players are equipped with improved earphones, sound leakage is almost absent, which means that the music players can be played at hazardous high volumes in most environments without disturbing other people.<sup>3,8</sup> The use of earbud-style earphones increases the volume level by another ~5.5 dB,<sup>3,9</sup> because of the smaller ear canal volume. Also, the recordings are made with much stronger compression, which allows for an average sound level closer to the maximal output level.

In noisy environments, listeners are especially likely to choose high volume settings,<sup>10</sup> which, over longer periods, are potentially hazardous.<sup>11</sup> The frequent use of an MP3 player is regarded as potentially hazardous in combination with other MP3 player-related, risky behaviors, particularly being exposed to high volumes. Besides risky behaviors such as using high volumes, increasing the volume after a period of listening because of a temporary threshold shift, and using earbud-style earphones, there are also protective behaviors, such as reducing the volume, taking breaks from listening, using a noise-limiter, and heeding warnings against the risks of high-volume music.

Some potential target groups and acceptable preventive measures were identified in a small qualitative study ( $N = 73$ ) exploring adolescents' perceptions regarding MP3 player-related topics such as risk perception and behavioral intentions.<sup>1</sup> For quantitative identification of important target groups and behaviors for hearing loss prevention,

more insight into adolescents' actual risky listening behaviors and actual protective listening behaviors is needed. Because no studies have provided such insight to date,<sup>2</sup> we examined (1) the extent to which, in their exposure to music through earphones on MP3 players, adolescents engage in risky behaviors such as listening at high volume settings (ie, more than three fourths), increasing the volume after a period of listening, and using earbud-style earphones; (2) the extent to which, in their exposure to music through earphones on MP3 players, adolescents engage in protective behaviors such as using a noise-limiter, reducing the volume after a period of listening, taking breaks from listening, and heeding warnings against the risks of high-volume music; and (3) any associations between both risky behaviors and protective behaviors, and both sociodemographic factors and using mode (frequency of use).

## METHODS

### Study Population

In 2007, we invited 1687 adolescents (age: 12–19 years) in 68 classes in 15 Dutch secondary schools to complete questionnaires on their music-listening behaviors, under supervision at school. Adolescents and parents received written information about the study; parents could refuse their child's participation, and participation by adolescents was voluntary and anonymous. The medical ethics committee of the Erasmus Medical Center (Rotterdam, Netherlands) approved the study.

### Questionnaire

Overall music-listening habits were assessed on the basis of 2 items (yes/no), that is, listening to music and listening to music for >3 hours/day. MP3 player use was assessed on the basis of 9 items, that is, use of MP3 player (yes/no), frequency of use (days per week), exposure time per day, level of volume control (very low, ~25%, ~50%, ~75%, or 100%), always or nearly always increasing the volume after a period of listening (yes/no), kind of earphone used (earbud-style, supraaural, or both types in alternation), always or nearly always using a noise-limiter (yes/no), always or nearly always reducing the volume level after a period of listening (yes/no), and always or nearly always taking breaks from listening (yes/no). We also recorded whether warnings against the risks of high-volume music were given by  $\geq 1$  person (yes/no) and, if so, whether such warnings always or nearly always were heeded (yes/no).

The questionnaire included items on the participant's gender, age, and educational level (practical prevocational, theoretical prevocational, senior general, or preuniversity), whether the participant shared a household with both his or her own father and mother (yes/no), and the country of birth of the participant and both parents (Appendix). Ethnicity (Dutch, Western migrant, or non-Western migrant) was determined on the basis of the country of birth of the mother and father, according to definitions of Statistics Netherlands.<sup>12</sup>

### Assessment of Using Mode

Users of MP3 players were classified according to 3 categories, that is, infrequent users (those who reported using their MP3 players an average of <1 hour/week), moderate users (those who reported using their MP3 players between 1 hour/week and 1 hour/day), and frequent users (those who reported using their MP3 players >1 hour/day).

### Analyses

Statistical analyses were performed by using SPSS 15 (SPSS Inc, Chicago, IL). Frequency tables were used to explore the characteristics of the total study population and MP3 player users. Mean and frequency differences of the total study population characteristics were examined through univariate analysis of variance and  $\chi^2$  statistics, respectively.

Within the subpopulation of MP3 player users, frequency tables and multiple logistic regression analyses were used to explore the associations between risky and protective listening behaviors and the using mode and sociodemographic characteristics. Any *P* values of <.05 were considered to be statistically significant.

## RESULTS

### Study Populations

The response rate was 89.9%. Four questionnaires were excluded because of incomplete data; 1512 questionnaires were used in the initial analyses. Participants' ages ranged from 12 to 19 years (mean: 14.7 years; SD: 1.21 years). Of the participants, 50.5% were male, 49.7% were attending prevocational secondary education, 86.4% were Dutch or a Western migrant, and 82.0% were living with both parents. The participants' sociodemographic characteristics reflected those of adolescents in the general Dutch population.<sup>12</sup> Of the participants, 89.9% reported listening to music through earphones on MP3 players.

Table 1 presents an overview of the characteristics of the total study population. Briefly, it shows that 73.7% of nonusers of MP3 players were male, 92.1% listened to music in general, and 16.4% listened to music for >3 hours/day. Slightly less than one half of MP3 player users were male (47.9%), 100% listened to music in general, and 26.1% listened for >3 hours/day (all *P* < .01).

### Using Mode, Risky Listening Behaviors, and Protective Listening Behaviors

Rates of reported risky listening behaviors ranged between 33.2% and 93.2%, and rates of reported protective listening behaviors ranged between 6.6% and 18.5%. Table 2 presents an overview of the behavioral characteristics of the MP3 player users in the study population; 32.8% were frequent users, 48.0% listened to high-volume music (ie, at a volume setting of more than three fourths), and 6.8% always or nearly always used a noise-limiter.

**TABLE 1** Characteristics of the Study Population (N = 1512)

	Total (N = 1512)	Not MP3 Player Users (N = 152)	MP3 Player Users (N = 1360)	P <sup>a</sup>
Sociodemographic characteristics				
Age, y				.33
Mean ± SD	14.7 ± 1.21	14.8 ± 1.29	14.7 ± 1.20	
Range	12–19	12–18	12–19	
Male, %	50.5	73.7	47.9	<.001
Secondary school type, %				.81
Practical prevocational	18.5	18.4	18.5	
Theoretical prevocational	31.2	34.2	30.9	
Senior general secondary	25.6	23.0	26.0	
Preuniversity	24.7	24.3	24.7	
Dutch or Western migrant, %	86.4	86.2	86.4	.91
Living with both parents, %	82.0	81.6	82.1	.83
General music exposure characteristics				
Listens to music (in general), %	99.2	92.1	100.0	<.001
Listens to music for >3 h/d, %	25.1	16.4	26.1	<.01
Listens to music through earphones on MP3 players, %	89.9	0.0	100.0	NA
Warned by ≥1 person against risks of high-volume music, %	72.3	67.1	72.9	.13

NA indicates not applicable.

<sup>a</sup> MP3 player users in comparison with non-MP3 player users.**Correlates of Risky Listening Behaviors**

Although more boys than girls listened to music at high volumes (odds ratio [OR]: 1.35 [95% confidence interval [CI]: 1.07–1.70]), fewer boys used earbud-style earphones (OR: 0.51 [95% CI: 0.32–0.80]) (Table 3). Relative to those attending preuniversity education, adolescents in practical prevocational schools listened to

high-volume music more often (OR: 2.63 [95% CI: 1.83–3.79]) and were more likely to increase the volume after a period of listening (OR: 3.14 [95% CI: 2.16–4.57]) (Table 3). In addition to listening to high-volume music more often than did those who lived with both parents, adolescents who did not live with both parents were more likely to increase the volume after a period of listening (both OR: 1.41 [95% CI: 1.03–1.93]). However, fewer of those adolescents used earbud-style earphones (OR: 0.56 [95% CI: 0.34–0.93]) (Table 3). Frequent users listened to high-volume music more often than did infrequent users (OR: 4.90 [95% CI: 3.64–6.61]), were more likely to increase the volume after some time (OR: 4.26 [95% CI: 3.10–5.86]), and were greater users of earbud-style earphones (OR: 1.99 [95% CI: 1.13–3.51]) (Table 3).

**TABLE 2** Behavioral Characteristics of MP3 Player Users in the Study Population (N = 1360)

	Proportion of MP3 Player Users, %
Frequency of use	
7 d/wk (in past month)	23.3
>3 h/d	9.7
Using mode	
Infrequent user <sup>a</sup>	31.9
Moderate user <sup>b</sup>	35.4
Frequent user <sup>c</sup>	32.8
Risky behaviors	
Listened to high-volume music (volume setting of more than three fourths)	48.0
Always or nearly always increased volume after some time during listening	33.2
Used earbud-style earphones	93.2
Protective behaviors	
Always or nearly always used noise-limiter	6.8
Always or nearly always reduced volume after a period of listening	6.6
Always or nearly always took a break for some time during listening	18.5
Always or nearly always heeded warnings against the risks of high-volume music	18.3

<sup>a</sup> MP3 player use for <1 hour/week.<sup>b</sup> MP3 player use between 1 hour/week and 1 hour/day.<sup>c</sup> MP3 player use for >1 hour/day.**Correlates of Protective Listening Behaviors**

When listening, adolescents 15.6 to 19.5 years of age took fewer breaks from music than did those 12.0 to 13.5 years of age (OR: 0.66 [95% CI: 0.44–0.99]) and were less likely to heed warnings against the risks of high-volume music (OR: 0.46 [95% CI: 0.30–0.70]) (Table 4). Non-Western migrants took more breaks than did Dutch individuals and Western migrants (OR: 1.61 [95% CI: 1.09–2.40]) (Table 4). Adolescents who did not live with both parents took fewer breaks than did those who lived with both parents (OR: 0.66 [95% CI: 0.44–0.99]) (Table 4). In addition to reducing the volume less often while listening, compared with infrequent users (OR: 0.43 [95% CI: 0.24–0.78]), frequent users took fewer breaks (OR: 0.35 [95% CI: 0.24–0.52]) and were less likely to heed warnings against the risks of high-volume music (OR: 0.47 [95% CI: 0.33–0.68]) (Table 4).

**TABLE 3** Frequencies and Multivariate ORs for Risky Behaviors According to Sociodemographic Factors and Using Mode (N = 1353)

Subgroups	Listened at Volume Setting of More Than Three Fourths		Always or Nearly Always Increased Volume After Period of Listening		Used Earbud-Style Earphones	
	Frequency, %	OR (95% CI)	Frequency, %	OR (95% CI)	Frequency, %	OR (95% CI)
Age						
12.0–13.5 y	38.4	1.00	27.3	1.00	93.5	1.00
13.6–14.5 y	46.6	1.13 (0.79–1.61)	33.0	1.01 (0.69–1.47)	92.4	0.79 (0.41–1.52)
14.6–15.5 y	51.8	1.29 (0.90–1.83)	36.1	1.09 (0.74–1.59)	93.4	0.98 (0.50–1.92)
15.6–19.5 y	52.0	1.30 (0.91–1.84)	34.6	1.00 (0.68–1.46)	93.7	0.99 (0.51–1.94)
Gender						
Female	44.4	1.00	30.6	1.00	95.3	1.00
Male	52.0	1.35 (1.07–1.70)	36.0	1.21 (0.95–1.55)	90.8	0.51 (0.32–0.80)
Educational level						
Practical prevocational	64.1	2.63 (1.83–3.79)	52.2	3.14 (2.16–4.57)	90.4	0.51 (0.26–1.00)
Theoretical prevocational	52.4	1.63 (1.19–2.22)	36.0	1.64 (1.17–2.29)	93.3	0.74 (0.39–1.41)
Senior general secondary	41.9	1.13 (0.81–1.56)	26.3	1.09 (0.76–1.57)	92.9	0.67 (0.35–1.29)
Preuniversity	36.9	1.00	22.9	1.00	95.2	1.00
Ethnicity						
Dutch or Western migrant	46.3	1.00	31.7	1.00	93.4	1.00
Non-Western migrant	59.6	1.30 (0.92–1.83)	43.7	1.29 (0.91–1.82)	91.3	0.81 (0.45–1.45)
Home situation						
Living with both parents	45.8	1.00	31.0	1.00	93.9	1.00
Not living with both parents	58.8	1.41 (1.03–1.93)	43.8	1.41 (1.03–1.93)	89.6	0.56 (0.34–0.93)
Using mode						
Infrequent user	29.4	1.00	18.3	1.00	91.7	1.00
Moderate user	46.1	1.99 (1.50–2.64)	30.7	1.93 (1.41–2.67)	92.9	1.27 (0.77–2.10)
Frequent user	68.2	4.90 (3.64–6.61)	50.0	4.26 (3.10–5.86)	95.0	1.99 (1.13–3.51)

## DISCUSSION

This study provides useful information on the prevalence of adolescents' risky and protective behaviors with regard to using MP3 players and on the associations between such behaviors and both demographic characteristics and using mode. Overall, our results demonstrate that, in their use of MP3 players, adolescents are much more likely to engage in risky behaviors than protective behaviors. Although longer exposure times are not dangerous by themselves, frequent use was associated positively with risky behaviors and was associated negatively with protective behaviors.

The participation rate in this study was high, and the characteristics of the study group were representative of those of the general population of Dutch adolescents.<sup>12</sup> We did not assess the hearing thresholds of the participants. Furthermore, we did not measure actual volume levels to which the adolescents were exposed. We relied on adolescents' self-reports. Because no studies on the reliability and validity of self-reports in this research area are available, there is a risk for both overreporting and underreporting.<sup>13</sup> Because the use of MP3 players might vary through the week and over time, future studies might consider the use of diaries to record use<sup>14</sup>; this might be a more-valid way of assessing risky and protective behaviors.

Although girls listened to music on MP3 players relatively more often than did boys and also used earbud-style earphones more often, boys listened at high volume relatively more often than did girls. This means that both genders were likely to be at risk of hearing loss. It

is not clear what poses the greatest threat to hearing conservation.

This study indicated that 2 important target groups for hearing loss prevention are adolescents in prevocational education and adolescents not living with both parents. The former result is in line with previous research,<sup>2,15</sup> in which adolescents at prevocational schools reported a lower level of parental influence than did their counterparts in preuniversity education. The likelihood that different adolescent groups will or will not engage in risky and protective behaviors may be influenced in part by parental monitoring.<sup>2</sup>

Parental monitoring is widely recognized as playing an important role in reducing adolescent risky health behavior.<sup>16</sup> This also might help explain the MP3 player-related behaviors of adolescents not living with both parents, especially if it is assumed that a single parent might find it more difficult than 2 parents to monitor a child's behavior. We recommend that future studies examine the role of parental monitoring in adolescents' music-listening behaviors. It is promising that we found that parents often did warn their children against the aural dangers of high-volume music; within the heeded warnings, the warnings by parents were heeded most often (data not shown).

Regardless of sociodemographic characteristics, frequent users reported a much higher frequency of risky listening behaviors than did infrequent users, ranging from twice as high to nearly 5 times as high. These users also reported a frequency of protective listening behaviors that was 2 to nearly 3 times lower than that of



**TABLE 4** Frequencies and Multivariate ORs for Protective Behaviors According to Sociodemographic Factors and Using Mode (N = 1353)

Subgroups	Always or Nearly Always Used Noise-Limiter		Always or Nearly Always Reduced Volume After Period of Listening		Always or Nearly Always Took Break for Some Time During Listening		Always or Nearly Always Heeded Warnings Against Risks of High-Volume Music	
	Frequency, %	OR (95% CI)	Frequency, %	OR (95% CI)	Frequency, %	OR (95% CI)	Frequency, %	OR (95% CI)
<b>Age</b>								
12.0–13.5 y	6.9	1.00	7.3	1.00	24.9	1.00	26.5	1.00
13.6–14.5 y	8.2	1.19 (0.64–2.24)	7.4	1.12 (0.60–2.09)	18.8	0.79 (0.53–1.18)	20.4	0.77 (0.52–1.14)
14.6–15.5 y	5.2	0.75 (0.38–1.50)	4.7	0.59 (0.29–1.21)	16.0	0.63 (0.41–0.95)	15.7	0.57 (0.38–0.87)
15.6–19.5 y	7.1	1.06 (0.56–2.02)	7.1	1.05 (0.56–1.97)	16.8	0.66 (0.44–0.99)	13.4	0.46 (0.30–0.70)
<b>Gender</b>								
Female	6.5	1.00	6.2	1.00	18.5	1.00	18.9	1.00
Male	7.2	1.12 (0.73–1.72)	7.1	1.20 (0.77–1.86)	18.6	1.03 (0.78–1.36)	17.6	0.96 (0.72–1.27)
<b>Educational level</b>								
Practical prevocational	6.8	1.10 (0.56–2.15)	6.0	0.91 (0.45–1.85)	18.3	0.97 (0.63–1.49)	10.8	0.40 (0.25–0.65)
Theoretical prevocational	5.0	0.79 (0.42–1.48)	7.1	1.14 (0.64–2.05)	18.8	0.94 (0.65–1.36)	19.8	0.79 (0.56–1.13)
Senior general secondary	9.6	1.60 (0.90–2.82)	6.2	0.99 (0.53–1.84)	16.1	0.75 (0.51–1.12)	15.3	0.54 (0.37–0.80)
Preuniversity	6.3	1.00	6.8	1.00	20.8	1.00	25.3	1.00
<b>Ethnicity</b>								
Dutch or Western migrant	7.1	1.00	6.3	1.00	18.0	1.00	18.2	1.00
Non-Western migrant	5.5	0.76 (0.38–1.51)	8.2	1.55 (0.85–2.81)	22.4	1.61 (1.09–2.40)	18.6	1.20 (0.79–1.83)
<b>Home situation</b>								
Living with both parents	6.9	1.00	6.8	1.00	19.6	1.00	18.3	1.00
Not living with both parents	6.7	1.00 (0.57–1.78)	5.0	0.72 (0.38–1.36)	13.8	0.66 (0.44–0.99)	18.3	1.06 (0.73–1.54)
<b>Using mode</b>								
Infrequent user	5.6	1.00	9.3	1.00	26.2	1.00	25.0	1.00
Moderate user	7.5	1.42 (0.83–2.44)	6.3	0.67 (0.41–1.11)	19.0	0.67 (0.49–0.93)	18.2	0.70 (0.51–0.97)
Frequent user	7.4	1.43 (0.82–2.49)	4.3	0.43 (0.24–0.78)	10.6	0.35 (0.24–0.52)	12.2	0.47 (0.33–0.68)

infrequent users. Assessment of the frequency with which adolescents use an MP3 player might be a feasible first step in the screening procedure for identifying adolescents most at risk for hearing loss. The frequency also might be a good screening variable for promoting education and protection.

In a focus group study, some adolescents reported not thinking consciously about their MP3 player-related listening behavior.<sup>1</sup> Therefore, we hypothesize that the frequency with which adolescents listen is automatically combined with specific risky listening behaviors when the adolescents start listening to their MP3 players. These automatic associations are plausibly explained through the concepts of habitual behavior and habit strength.<sup>17</sup> These MP3 player-related listening patterns might be a natural part of adolescents' everyday lives that do not require any intentional effort to be set in motion; the behaviors seem to be habitual and therefore might be difficult to change.<sup>18</sup> Future research should include investigation of the role of habit strength in MP3 player-related behaviors.

Given the high prevalence of risky behaviors and the low prevalence of protective behaviors, the results suggest that the levels at which adolescents engage in these behaviors justify the development and implementation of strategies for prevention and intervention. Information about the prevalence of adolescents' risky and protective behaviors and the associations of such behaviors with demographic characteristics and frequency of use, as provided in this study, is necessary to enhance both health education aimed at promotion of protective be-

haviors among the adolescents themselves and health protection measures aimed at rules, regulations, and facilities to protect adolescents from such exposure. For the development of effective health education, however, further research on specific motivating factors for and barriers to protective behaviors and how these differ between target groups and other adolescent groups is needed.

Because the use of MP3 players starts early in life, we suggest that prevention at elementary school age would be the most effective way of increasing children's awareness of the risks of high-volume music. Before the risky behaviors became habitual, children could gain an understanding of healthy listening behaviors, the consequences of hearing loss, and the protective measures that are possible. Teachers and other involved professionals, including pediatricians and general practitioners, might play important roles in modifying and intervening in children's awareness and behaviors and in promoting parental involvement.

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## APPENDIX Survey Items

### Sociodemographic characteristics

- Are you a boy or a girl?
- What is your date of birth?
- What kind of education do you attend?
- With whom do you share a household?
- What is your country of birth?
- What is your father's country of birth?
- What is your mother's country of birth?

### Music exposure

- Overall music exposure
  - Do you ever listen to music?
  - How long do you normally listen to music each day?
- MP3 player exposure
  - Do you ever listen to music through earphones on a portable music player (MP3 player)?
  - On average in the past month, on how many days per week did you listen to music on an MP3 player?
  - How long do you normally use your MP3 player each day?
  - At what volume-control level do you normally listen?
  - When listening to music through earphones, how often do you increase the volume after a period of listening?
  - What kind of earphones do you normally use?
  - How often do you use a noise-limiter on your MP3 player?
  - When listening to music through earphones, how often do you reduce the volume after a period of listening?
  - When listening to music through earphones, how often do you take breaks from listening?
  - Who has ever warned you that listening to very high-volume music can be dangerous to your hearing?
  - How often do you heed such warnings, for example, by reducing your music volume?

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