Age, Academic Performance, and Stimulant Prescribing for ADHD: A Nationwide Cohort Study

WHAT'S KNOWN ON THIS SUBJECT: The impact of relative age at school entry on academic progress and the risk of being diagnosed with ADHD remains controversial. Stimulants are widely used as a therapeutic option for ADHD in the United States and increasingly in Europe.

WHAT THIS STUDY ADDS: Relative age among classmates affects academic performance among boys and girls into puberty, as well as children's risk of being prescribed stimulants for ADHD. This should be taken into account when evaluating children's performance and behavior in school to prevent unnecessary stimulant prescribing.

abstract

BACKGROUND: We evaluated whether younger age in class is associated with poorer academic performance and an increased risk of being prescribed stimulants for attention-deficit/hyperactivity disorder (ADHD).

METHODS: This was a nationwide population-based cohort study, linking data from national registries of prescribed drugs and standardized scholastic examinations. The study population comprised all children born in 1994–1996 who took standardized tests in Iceland at ages 9 and 12 (n = 11 785). We estimated risks of receiving low test scores (0–10th percentile) and being prescribed stimulants for ADHD. Comparisons were made according to children's relative age in class.

RESULTS: Mean test scores in mathematics and language arts were lowest among the youngest children in the fourth grade, although the gap attenuated in the seventh grade. Compared with the oldest third, those in the youngest third of class had an increased relative risk of receiving a low test score at age 9 for mathematics (1.9; 95% confidence interval [CI] 1.6–2.2) and language arts (1.8; 95% CI 1.6–2.1), whereas at age 12, the relative risk was 1.6 in both subjects. Children in the youngest third of class were 50% more likely (1.5; 95% CI 1.3–1.8) than those in the oldest third to be prescribed stimulants between ages 7 and 14.

CONCLUSIONS: Relative age among classmates affects children's academic performance into puberty, as well as their risk of being prescribed stimulants for ADHD. This should be taken into account when evaluating children's performance and behavior in school to prevent unnecessary stimulant treatment. *Pediatrics* 2012;130:1012–1018

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KEY WORDS

relative age, academic performance, stimulant prescribing, ADHD, children

ABBREVIATIONS

ADHD—attention-deficit/hyperactivity disorder
CI—confidence interval

Drs Zoëga, Valdimarsdóttir, and Hernández-Díaz are responsible for the reported research, have seen and approved the final version of the manuscript, and have taken due care to ensure the integrity of the work. All authors made substantial contributions to the conception and design of the study. Drs Zoëga and Valdimarsdóttir contributed to the acquisition of data. Drs Zoëga, Valdimarsdóttir, and Hernández-Díaz authors took active part in the analysis and interpretation of data and the drafting and revising of the manuscript. All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Dr Hernández-Díaz is the guarantor of this study.

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Every year a new birth cohort of millions of children starts school.[1] Birthday cutoffs for school entry necessarily lead to an age span of at least 12 months within a classroom. At age 5, this span accounts for 20% of the child's age and presents a difference in maturity and performance between the youngest and the oldest child in class.[2] Whether the apparent gap in performance persists is controversial. Earlier studies indicated that being older relative to one's classmates has no long-term benefits[3] and may even imply increased risk of behavioral problems.[4] However, more recent studies suggest that a relative maturity disadvantage in childhood could have long-lasting negative effects on personal achievements and health outcomes.[5-7] In addition, recent evidence suggests that the youngest children in the classroom are more often treated for attention-deficit/hyperactivity disorder (ADHD),[8,9] a childhood diagnosis that may have lasting effects through adolescence and into adulthood.[10,11]

Even when the long-term benefits of being older relative to peers are still unclear, children are sometimes red-shirted (ie, parents hold them back for a year before entering school) so that they will be more mature and thus start off with an academic, social, and physical advantage. For the same reasons, regions and school districts have pushed back their birthday cutoffs to increase the average age of the children and thus improve their standardized tests scores later.

Concrete evidence on the effect of relative age at school entry on ADHD and longer-term academic achievement can be crucial for educators, health care providers, parents, and policymakers. First, understanding these associations may have an impact on the evaluation of maturity differences and academic performance in the classroom. Second, such evidence could inform diagnostic criteria guidelines for ADHD and may circumvent unnecessary ADHD drug treatment in children who are "acting their age" in school. Moreover, it would have implications for basic decisions about when parents may want to start their children in school and what education policymakers recommend on standardized testing and birthday cutoffs.

Leveraging the homogenous setting and unique national registration of health and academic outcomes in Iceland, we aimed to elucidate the impact of relative age at school entry on later academic progress and ADHD treatment, taking into account potential sex differences. Use of stimulants for ADHD in Iceland has previously been shown to be high and on par with utilization rates in the United States.[12,13] We hypothesized that a relatively young age at school entry adversely affects academic performance among children at ages 9 to 12. Furthermore, we hypothesized that being young relative to one's classmates increases the risk of being prescribed stimulant drugs for ADHD.

METHODS

Setting and Population

We obtained nationwide data from January 1, 2003, to January 1, 2009 on standardized test results and psychotropic drug prescription fills for 3 national birth cohorts in Iceland. For all children born in 1994, 1995, and 1996 and registered in the Icelandic school system during the study time (n = 13 617), we linked nationwide records from the Database of National Scholastic Examinations, the Icelandic Population Registry, and the Icelandic Medicines Registry, via personal identification numbers given to each Icelandic citizen at birth and to residents on immigration. The primary study population comprised all children who took a standardized test in both fourth (age 9) and seventh grade (age 12; n = 11 872).

Measures

From the Population Registry, we obtained data on gender, month, year and place of birth (urban, rural, outside Iceland). The Registry has complete information on these variables. We divided children into 3 relative age groups depending on month of birth; the oldest third in the school cohort (January to April), middle third (May to August), and youngest third (September to December). Relative age in the Icelandic classroom coincides with the order of calendar months given the nationwide birthday cutoff, January 1; children start school in September of the calendar year in which they turn 6.

The primary outcome measures included standardized test scores in mathematics and language arts. These are nationally coordinated assessments, mandatory for all children in fourth grade (age 9) and seventh grade (age 12). They measure similar grade-adjusted components in both grades. We obtained the test scores, test dates, school, and school region for each child who took tests in both grades in 2003–2008. Tests are scored on a scale of 0.0 to 10.0. We converted these to a percentile scale (0–100) that was ranked within each test year. We defined a low test score as ranking in the lowest decile (0–10th percentile). We assessed change in academic performance over time by subtracting the percentile score each child received in seventh grade from the percentile score he or she received in fourth grade.

The secondary outcome was the prescription of stimulants for ADHD, that is, the filling of ≥1 such drug prescription during the entire study period and between tests in fourth and seventh grade only. The Icelandic Medicines Registry contains information for each person dispensed prescription drugs as an outpatient since January 1, 2003. Completeness ranges from 93.7% to 99.9% of all filled prescriptions to outpatients in 2003–2009. We defined ADHD drugs according to the World Health Organization Anatomic Therapeutic Chemical classification as drugs within the category of centrally acting sympathomimetics (N06BA).[14] Chemical substances included were amphetamine (N06BA01), methylphenidate (N06BA04), and the nonstimulant atomoxetine (N06BA09). The Medicines Registry does not hold information on the indication for drug treatment. In Iceland, however, an ADHD diagnosis must be verified by a pediatric, psychiatric, or neurological specialist for reimbursement of these drugs. Thus, it is reasonable to assume that essentially all medicated children fulfilled the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, criteria[15] for ADHD before filling a prescription for stimulant drugs.

Data Analysis

Of the 13 617 children born 1994 to 1996 and registered in the Icelandic school system, 11 785 (87%) participated in ≥1 standardized tests in both fourth grade (age 9) and seventh grade (age 12). Test participation did not vary significantly by relative age at school entry or by demographic and baseline characteristics. Of the 11 872 test participants, 87 (0.7%) children were either 1 year ahead or behind at the time of testing. We excluded these children to avoid any effect of grade acceleration or retention on the study results. Available for analysis were thus in total 11 785 children; 11 659 in fourth-grade mathematics; 11 653 in seventh-grade mathematics; 11 559 for mathematics in both grades; 11 629 in fourth-grade language arts; 11 602 in seventh-grade language arts, and 11 483 for language arts in both grades. We calculated the mean percentile score on fourth and seventh grade tests and mean percentile score change between grades, according to children's gender and relative age (born in January–April, May–August, or September–December). We then estimated risks and risk ratios for receiving a low test score, as well as for being prescribed stimulants for ADHD (filling ≥1 prescription). For stratified analyses, we used the Mantel-Haenszel method.[16] We present crude estimates because, as expected, birth month was not associated with the characteristics of the study cohort: gender, birth year, place of birth, and school region (see Supplemental Table 2). Neither controlling for these factors one by one nor adjustment for all simultaneously with modified Poisson regression analysis changed the estimates.[17]

We used PASW Statistics (version 18) and Excel spreadsheets to run analyses. This study was approved by the National Bioethics Committee (VSNb2008040016/03-7) and the Data Protection Authority (2008040343) in Iceland.

RESULTS

Test Scores

Mean test scores in both mathematics and language arts were lowest among the youngest children in class and increased linearly with relative age (Fig 1). On standardized tests at age 9, the youngest third ranked on average 10.6 percentiles lower in mathematics and 10.2 percentiles lower in language arts than children in the oldest third. From age 9 to 12 (fourth- to seventh-grade tests), mean percentile score change in mathematics was 1.9, 0.1, and –2.1, respectively, for children in the youngest, middle, and oldest third in class. In language arts the mean percentile score changes was 1.3, 0.1, and –2.0, respectively, for children in the youngest, middle, and oldest third in class. Despite varying changes in mean percentile score by relative age, children in the youngest third still ranked significantly lower than children in the oldest third of class on seventh-grade tests in mathematics (6.6 percentiles lower) and language arts (6.9 percentiles lower).

Children in the youngest third of class were, compared with the oldest third, at increased risk of receiving a low test score in mathematics and language arts (Table 1). In fourth grade, the relative risk increase was 90% in mathematics and 80% in language arts, whereas in seventh grade, it was 60% in both subject areas.

Overall, girls scored higher than boys on both fourth- and seventh-grade tests, especially in language arts (Fig 1). However, the relative age effect on academic performance was observed both in boys and girls (Table 1).

ADHD Stimulant Treatment

Of the study cohort, 740 children (6.3%) were prescribed stimulants for ADHD at some time point in 2003–2009, including 308 (8.0%) children born in the youngest third, 230 (5.6%) in the middle third, and 202 (5.3%) in the oldest third. During the 6 years of follow-up, children in the youngest third of class were thus 50% more likely (95% confidence interval 28%–80%) than those in the oldest third to be prescribed stimulants for ADHD. Neither stratifying by children's birth year nor considering prescriptions only filled between fourth and seventh grade meaningfully changed the relative age effect. Use of stimulants was lower in girls than in boys, but for both sexes, use was most common in the relatively youngest (Fig 2).

DISCUSSION

The results of this population-based, nationwide study indicate that being

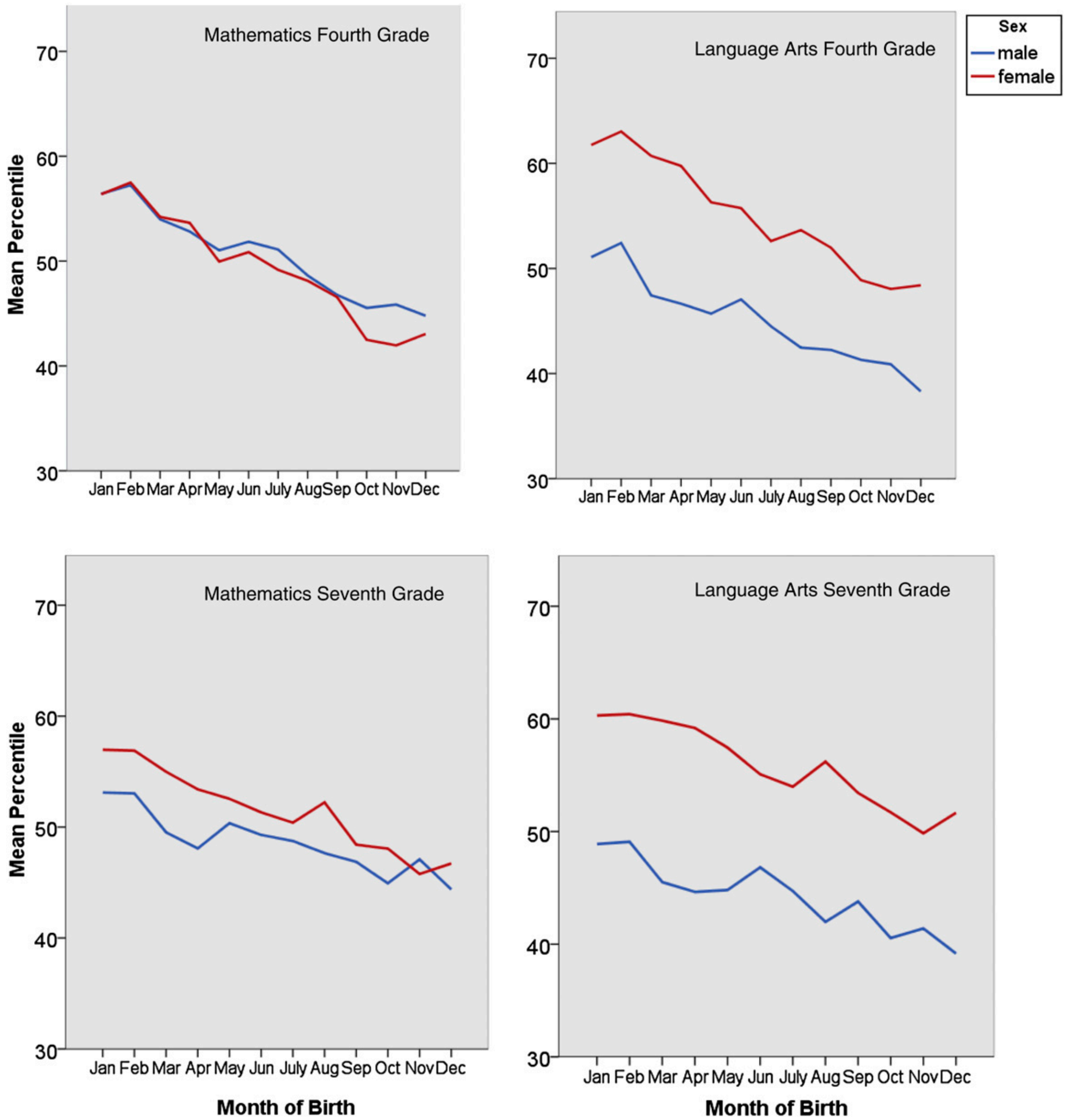

FIGURE 1
Performance on standardized achievement tests mandatory for all children in fourth (age 9) and seventh (age 12) grades in Iceland according to relative age in class (*N* = 11 785).

among the youngest students in class is associated with academic underperformance during childhood. We found that at age 9, the youngest third of children in their class had, compared with the oldest third, an 80% to 90% increased risk of scoring in the lowest decile on standardized tests. At age 12, this excess risk was 60% for both mathematics and language, indicating that the effect of relative age on academic achievement might ameliorate over time but is still at play into puberty. Furthermore, over 6 years of follow-up, the youngest third of children in class were 50% more likely than the oldest third of their classmates to be prescribed stimulants for ADHD.

The strength of the study lies in its design, which allowed us to follow the same children over time for both academic outcomes and ADHD treatment. Furthermore, given the nature of the exposure of interest (ie, birth month), this observational study is a quasi-randomized natural experiment, with comparable risk factors distribution among relative age groups within a grade, except for season of birth. It has been hypothesized that season of birth is a biological risk factor for ADHD related to viral infections in early life.[18] However, findings do not support the presence of seasonal effects: studies across geographic regions with different birthday cutoffs for school entry show

TABLE 1 Risks and Risk Ratios[a] of Low Academic Scores (Lowest Decile) Stratified by Gender and ADHD Drug Treatment, According to Relative Age in Class

	Oldest third, crude risk % (*n*/*N*)	Youngest third, crude risk % (*n*/*N*)	Youngest third versus oldest third, risk ratio (95% CI)[b]
Low mathematics score fourth grade			
Total	7 (251/3794)	13 (479/3800)	1.9 (1.6–2.2)
Gender			
Boys	7 (125/1931)	12 (234/1906)	1.9 (1.5–2.3)
Girls	7 (126/1863)	13 (245/1894)	1.9 (1.5–2.3)
Low language arts score fourth grade			
Total	7 (277/3785)	13 (487/3775)	1.8 (1.6–2.1)
Gender			
Boys	10 (193/1915)	16 (309/1879)	1.6 (1.4–1.9)
Girls	5 (84/1870)	9 (178/1896)	2.1 (1.6–2.7)
Low mathematics score seventh grade			
Total	7 (281/3799)	12 (457/3788)	1.6 (1.4–1.9)
Gender			
Boys	9 (169/1931)	13 (250/1895)	1.5 (1.3–1.8)
Girls	6 (112/1868)	11 (207/1893)	1.8 (1.5–2.3)
Low language arts score seventh grade			
Total	8 (299/3788)	12 (465/3773)	1.6 (1.4–1.8)
Gender			
Boys	11 (212/1913)	17 (314/1876)	1.5 (1.3–1.8)
Girls	5 (87/1875)	8 (151/1897)	1.7 (1.3–2.2)

[a] Risk ratios for the youngest third in class (born September to December) using the oldest third (born January to April) as the reference group.

[b] Crude risk ratio. The multivariable adjusted risk ratio controlling for birthplace (urban, rural, outside Iceland), school region in fourth/seventh grade (urban, rural), calendar year, and, when not stratified, gender (boy, girl) changed the crude ratios only to the second digit and are therefore not shown.

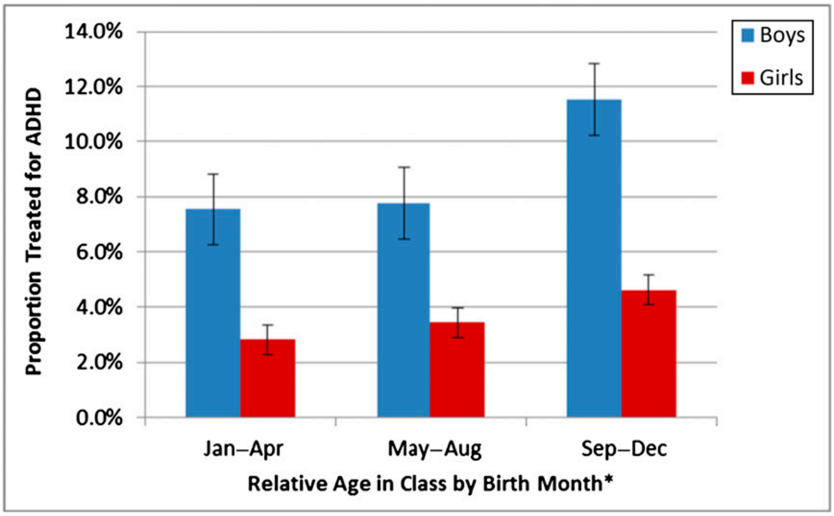

FIGURE 2
Proportion of study population treated with drugs for ADHD anytime in 2003–2009, according to relative age in class. *Oldest third, children born January to April; middle third children born May to August; youngest third children born September to December (N = 11 785).

that children born shortly before their designated cutoff date have academic disadvantages.[5,6,8] Similarly, we found a linear trend of academic performance and ADHD prescriptions with birth month; the most pronounced differences were between children born in the months right before and after the birthday cutoff for school entry (youngest vs oldest thirds in class), rather than between those born in different seasons (winter vs summer).

On the other hand, the study setting may limit the generalizability of our results. Iceland has publicly funded universal health care and education, structural and cultural factors likely to influence academic achievement and access to health care. Moreover, our outcomes were standardized test scores and the prescription of stimulant drugs between ages 7 and 14, which may only partially predict long-term academic achievements and psychiatric health. Finally, the nature of the data prevents us from ruling out the possibility of undertreatment of ADHD among the oldest children in class rather than, as we hypothesize, excess treatment among the youngest.

By analyzing standardized test scores in mathematics and science from multiple countries, Bedard and Dhuey provided evidence of the persistence of early childhood maturity effects on academic performance and how it might be exaggerated into adulthood through the educational system.[5] Consistent with our results, they found that the youngest students in class, born in the last month before school entry cutoff, performed 4 to 12 percentiles worse at age 9, and 2 to 9 percentiles worse at age 13, compared with peers in the same grade born in the first month after the cutoff. The youngest children in class were also less likely to enter high-end universities. In addition, when compared with their relatively older peers, those younger have been shown to be less likely to excel in sports[7] and to be at higher risk of emotional and behavioral problems.[6] Our study brings forward strong data that the relative age effect not only applies to science and mathematics but also language arts.

Recently, Elder showed that the youngest children in fifth and eighth grades are nearly twice as likely as their older classmates to use stimulants prescribed for ADHD and argued that the diagnosis was largely driven by subjective comparisons across children in the same grade in school.[8] In a cohort of almost 12 000 US children followed from kindergarten to eighth grade, he found that 8.4% of the youngest children the classroom, born in the month before their state's cutoff date for kindergarten eligibility, were diagnosed with ADHD, compared with 5.1% of children born in the month immediately after the cutoff date. Similarly, based on 3 samples of large scale cross-sectional US survey data, Evans et al found that children 7 to 17 years old whose birthday fell in the 120 days before school eligibility cutoff date had, compared with those born in the 120 days after cutoff, double the chance of being diagnosed with or treated for ADHD.[9] These findings corroborate our results. Whether children who start stimulant treatment for ADHD benefit academically is a topic of another study, but our previous results indicate that earlier treatment is associated with a lower risk of decline in academic performance.[19]

The association of children's relative age to peers in class with both academic performance and ADHD treatment may not be surprising. ADHD may affect academic performance, and academic performance may affect ADHD diagnosis. The diagnosis of ADHD in children is a several-step process based on clinical evaluation, teacher ratings of behavior and performance in school, and parental rating scales.[20] The *Diagnostic and Statistical Manual of Mental Disorders* standard requires symptoms to be present in ≥2 settings (eg, at school and home) with evidence of clinically significant impairment in social or school/work functioning.[15] Because classic ADHD in early childhood is a neurodevelopment disorder,[21,22] the increased risk of an ADHD diagnosis in the youngest children in class could partially be a mere consequence of their immaturity relative to older peers. The potential lifelong consequences of labeling children with a psychiatric disorder and exposing them to stimulants warrants further evaluation and would need to be balanced against the benefits of early intervention.

The sex differences in our data are noteworthy. Overall, girls performed better academically than boys, especially in language arts, and the gender difference remained into puberty. The youngest third of girls scored similar to, or even higher than, the oldest third of boys in class on tests in language arts, suggesting that gender might be a stronger indicator for academic performance than relative age. In accordance with previous studies and clinical data, girls were less frequently treated for ADHD than boys.[23,24] Despite these gender differences in academic performance and stimulant use, we note that the observed associations of relative age with academic performance and stimulant prescribing hold for both girls and boys.

CONCLUSIONS

Relative age among classmates and gender play a role in both academic performance and risk for ADHD treatment throughout childhood and into puberty. Educators and health care providers should take relative age and gender into account when evaluating children's performance in school and other criteria for ADHD diagnosis. These findings can inform the decision of parents with children born close to birthday cutoffs regarding school entry.

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WHEN THE MUSIC STOPS: *Growing up, a piano was a prized possession. Not only was it a symbol of economic success, it often was the focal point of the house. Children practiced scales, and adults congregated around the piano to sing well-known songs or create new ones. When my aunt died, her cherished piano was passed on to her daughter. However, according to an article in* The New York Times *(Arts: July 30, 2012), many pianos are no longer cherished. In fact, they are unceremoniously being dumped into landfills and trash-transfer stations across the nation, their hundreds of pounds of broken wood and metal being sold for scrap or even burned. The reason for the destruction is multifactorial. Peak production of pianos in the United States occurred between 1900 and 1930. In 1910, nearly 365,000 were sold. Pianos last 80 years on average, so many produced in the early part of the 20th century have reached the end of their useful musical lifetime. Unfortunately, maintaining a piano is quite costly, with thousands of moving parts requiring hours of labor by highly trained technicians. With so many older pianos on the market, many requiring costly repair work, prices have tumbled. Few pianos, other than those made by Steinway or other high end manufacturers, have retained value. Most customers, faced with the decision as to whether to buy an old piano or a new, inexpensive imported piano with good sound choose the latter. Even more opt to buy a keyboard—which can be purchased for a few hundred dollars, sounds great, and essentially requires no upkeep. In 2011, approximately 1.1 million keyboards were sold in the US, compared to only 41,000 pianos. While piano owners and haulers lament the decline of the piano, it is easier and cheaper to dispose of them than to maintain them. We still have an upright from my mother-in-law. We rarely tune it, but I still love hearing my son play. At least for this old piano, no visit to the dump is planned.*

Noted by WVR, MD