INTRODUCTION
Children with hearing loss experience greater difficulty understanding speech in noise and in reverberant conditions. The adverse effects range from difficulty in class, decreased motivation, and reduced learning potential. This reduction in available processing resources is thought to cause increased listening effort, stress, and fatigue.

Classroom noise and fatigue are complex interacting factors. Individuals who have difficulty hearing speech in noise are often required to devote a great deal of effort to decoding the audio input. They are often left with the impression that they may be impaired in their ability to understand conversational speech. Children with hearing loss may be more prone to develop chronic stress and subsequent fatigue.

METHODS
Data were obtained as part of a larger ongoing study examining listening effort and fatigue in school children with normal hearing. A secondary purpose was to examine if classroom noise level has an effect on stress and fatigue in children with hearing loss.

RESULTS
The purpose of this study was to determine if children with hearing loss show different patterns of stress and fatigue when compared to children with normal hearing. A secondary purpose was to examine if classroom noise level has an effect on stress and fatigue in children with hearing loss and children with normal hearing.

Figure 1. Hair cortisol levels in the children with hearing loss.

Figure 2. Mean cortisol levels (standard error bars) at all times of collection for children with normal hearing (filled squares) and with hearing loss (open squares). This includes children with missing data points. These data show a greater percentage of children with normal hearing show the expected pattern of cortisol level decreased as the day progressed, whereas data below zero indicate the child's recorded salivary cortisol level increased from morning to afternoon. Based on salivary cortisol patterns in humans, we would expect cortisol levels to decrease from morning to afternoon, thus showing data falling above zero on this chart.

Figure 3. One child with hearing loss showed a cortisol pattern that deviated from the rest of the children with hearing loss. The child's data, averaged across both days, are shown along with the mean data from children with normal hearing and children with hearing loss. It is unknown if this child was using hearing technology at the time of data collection and analysis during the school day were reported as typical.

Figure 4. Individual classroom noise levels obtained during morning and afternoon visits on both school days are shown in this figure. The average recorded classroom noise level was 64.64 dB (HL) or pure tone air conduction thresholds greater than 25 dB HL at two or more frequencies above 2 kHz (i.e. 3, 4, 6, 8 kHz) at least 20 dB HL in both ears from 250-8000 Hz.

Table 2. Characteristics of device use for children with hearing loss during 10:30am and 2:30pm data collection on both school days. Children ages 7-10 years were consistent users of hearing technology whereas children ages 11 and 12 years used hearing aids sporadically and rarely used FM systems in the classroom.

SUMMARY & CONCLUSIONS
Children with hearing loss showed altered cortisol awakening responses, suggesting the possibility of chronic stress and subsequent fatigue.

Classroom noise levels continued to exceed minimal recommended standards for classroom education.

Classroom noise levels did not appear to affect changes in cortisol levels from morning to afternoon. Although cortisol levels are expected to fall through the day, preliminary data suggest this pattern may be reversed for some children with hearing loss. Further research is needed to determine factors that may affect the cortisol pattern such as age, severity of hearing loss, technology use, and classroom noise levels.

Younger children with hearing loss in this study were consistent users of hearing aids and FM systems in the school setting. Children ages 11-12 years exhibited reduced hearing aid use at school days are shown along with the mean data from children with normal hearing and children with hearing loss. It is unknown if this child was using hearing technology at the time of data collection and analysis during the school day were reported as typical.

Figure 5. Difference in cortisol levels at 10:30am and 2:30pm are shown as a function of average classroom noise level for children with normal hearing (filled squares) and children with hearing loss (open squares). These data are shown in Figure 4. Children with hearing loss exhibited higher cortisol levels at awakening and at 30 and 60 min post awakening when compared to children with normal hearing. This suggests a greater cortisol awakening response. Increased cortisol awakening responses are associated with chronic stress, perceived stress, and scoring about the burden of the upcoming day7. As the day progresses, children with hearing loss showed cortisol patterns similar to children with normal hearing.

In general, children showed varied cortisol changes in response to classroom noise levels. In our sample, a greater percentage of children with normal hearing showed the expected pattern of decreasing cortisol while half of the children with hearing loss show an increase of cortisol from morning to afternoon. These patterns do not appear to be related to the level of classroom noise.