

Prevalence of Hearing Loss among Hospital Births in Michigan, 2009–2013



A report prepared by the

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Background Information

Hearing loss is one of the most common disabilities and has lifelong consequences for affected children and their families. Early detection and appropriate intervention is critical to speech, language and cognitive development in hearing-impaired children.¹ Some risk indicators for congenital or late-onset hearing loss include caregiver concern, family history of hearing loss, in utero infections such as cytomegalovirus (CMV), craniofacial anomalies, neurodegenerative disorders, head trauma, NICU stays of more than 5 days, ECMO and chemotherapy.² Early and more frequent assessment may be indicated for children with risk factors.² All infants, with or without risk factors, should receive ongoing surveillance of communicative development beginning at two months of age.³ Infants with confirmed hearing loss should receive appropriate intervention by six months of age.² Nationally, about one to three infants per 1,000 births are diagnosed with permanent hearing loss. From 2009 to 2013, the prevalence of permanent hearing loss among hospital births in Michigan was 1.8 cases per 1,000 live births. The Michigan Early Hearing Detection and Intervention (EHDI) program conducted a study to assess information on the number of babies identified with hearing loss, in response to a request from a large hospital system that suspected that they were identifying a lower than expected number of children with permanent hearing loss. The purpose of this study was to compare the prevalence of permanent hearing loss by birth hospital size in Michigan.

Methods

EHDI data was obtained from the EHDI Data System for birth years 2009 through 2013. Live birth data per hospital was obtained from the Division of Vital Records and Health Statistics for the same years in order to calculate the prevalence of permanent hearing loss by hospital. Results were analyzed using Statistical Analysis Software (SAS) 9.2 [SAS Institute, Cary, NC] for univariate and bivariate analysis, as well as descriptive statistics and statistical significance where applicable. Using quantile statistics, we grouped all 84 Michigan birth hospitals into four equal categories of size, according to the quartile distribution of the average number of births across the five years. Poisson regression was used to test for significance in trend data. Using a one-way analysis of variance (ANOVA) model, we tested for an association between hospital size and the prevalence of permanent hearing loss. Results in this report are based only on hospital births; out of hospital births were excluded. Hospitals whose status changed and are no longer designated as birthing hospitals and facilities that had no births were also excluded.

Results

Data Overview: 2009-2013

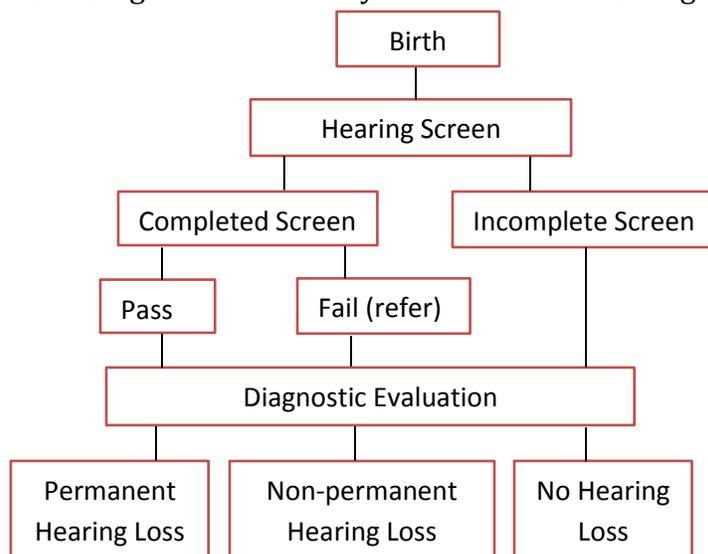
A brief summary of the number of live births, infants with complete hearing screens, those who referred from a final screen and those who received a diagnostic evaluation, as well as the number and prevalence of hearing loss are shown in Table 1.

Table 1: Summary Statistics for All Birth Hospitals: Michigan EHDI, 2009-2013

Indicator	Number	Percent	Rate Calculations
Number of Live births (a)	556,737		
Complete initial screen (b)	553,043	99.3	(b/a × 100%)
Refer from final screen (did not pass) (c)	6,827	1.2	(c/b × 100%)
Diagnostic evaluation (d)	4,995		
Diagnostic evaluation after referral from final screen (e)	3,159	46.3	(e/c × 100%)
Permanent hearing loss (f)	1,012	20.3	(f/d × 100%)
Non-permanent hearing loss (g)	525	10.5	(g/d × 100%)
Prevalence of permanent hearing loss	1.8 per 1,000 live births		(f/a × 1000)
Prevalence of non-permanent hearing loss	0.9 per 1,000 live births		(g/a × 1000)

From 2009 to 2013, there were 556,737 hospital live births in Michigan, of which 99.3% (n=553,043) had a complete initial screen and of these, 1.2% (n=6,827) referred (did not pass) from the final screen (Table 1). Of those who referred from the final screen, 46.3% (n=3,159) received a diagnostic evaluation (Table 1). From 2009 to 2013, 4,995 Michigan infants had a diagnostic evaluation, 20.3% (n=1,012) were diagnosed with permanent hearing loss and 10.5% (n=525) were diagnosed with non-permanent hearing loss (Table 1). The prevalence of permanent hearing loss for all hospital births in Michigan from 2009 to 2013 was 1.8 (95% CI: 1.7-1.9) cases per 1,000 live births (Table 1). The prevalence of non-permanent hearing loss among all hospital births in Michigan from 2009 to 2013 was 0.9 (95% CI: 0.8-1.0) cases per 1,000 live births (Table 1). Figure 1 below displays a flow chart showing how infants proceed through the EHDI system from birth to diagnosis.

Figure 1: Stages of the EHDI System from Birth to Diagnosis



Live Births by Hospital Size: 2009-2013

The number of live births per hospital was analyzed, in order to group hospitals by size for hearing loss prevalence comparison. Table 2 shows the range of the average number of live births across the five years for Michigan hospitals grouped by size. Birth hospitals were grouped into four categories by dividing the distribution of the average number of births into four quartiles. The hospitals were grouped into four even categories based on the percentile of the average number of births; each category comprised of 21 birth hospitals (Table 2).

Table 2: Birth Hospital Size by Average Number of Births (Range): Michigan Vital Records and Health Statistics, 2009-2013

Birth Hospital Size	Range of Average Number of Births
Small (n=21)	85 - 380
Small-Medium (n=21)	383 - 744
Medium (n=21)	816 - 1,718
Large (n=21)	1,741 - 7,517

Birth hospitals were grouped by small, small-medium, medium and large sizes with reference to their percentile of the average number of births, corresponding to the quartile distribution – 1st quartile (25th percentile), median (50th percentile), 3rd quartile (75th percentile) and 4th quartile (100th percentile; Table 2). The average number of live births ranged from 85 to 7,517 for all birth hospitals (Table 2).

Complete Hearing Screens by Hospital Size, 2009-2013

Complete hearing screen results were analyzed by birth hospital size to show the percent of live births in each hospital category that received a complete hearing screen from 2009 to 2013 (Table 3).

Table 3: Complete Hearing Screens by Birth Hospital Size: Michigan EHDI, 2009-2013

Birth Hospital Size	Live Births	Complete Screens	Percent
Small	29,964	29,660	99.0
Small-Medium	59,428	58,879	99.1
Medium	130,169	129,119	99.2
Large	337,176	335,385	99.5
All hospitals	556,737	553,043	99.3

From 2009 to 2013, of all hospital live births in Michigan (n=556,737), 99.3% (n=553,043) had a complete hearing screen (Table 3). Small birth hospitals had a 99.0% screen rate, small-medium

hospitals had a 99.1% screen rate, medium hospitals had a 99.2% screen rate and large hospitals had a 99.5% screen rate (Table 3).

Hearing Screen Results by Hospital Size, 2009-2013

The final hearing screen results for infants who received a hearing screen among all hospital live births from 2009 to 2013 are presented in Table 4 below. Results are broken down by birth hospital size and indicate the percent of infants with a pass, fail or incomplete final screen result. Incomplete final screens are screens that were not able to be completed due to hospital, parental or infant related issues with no further screening. These do not include infants with a missing hearing result.

Table 4: Final Screen Results by Birth Hospital Size: Michigan EHDI, 2009-2013

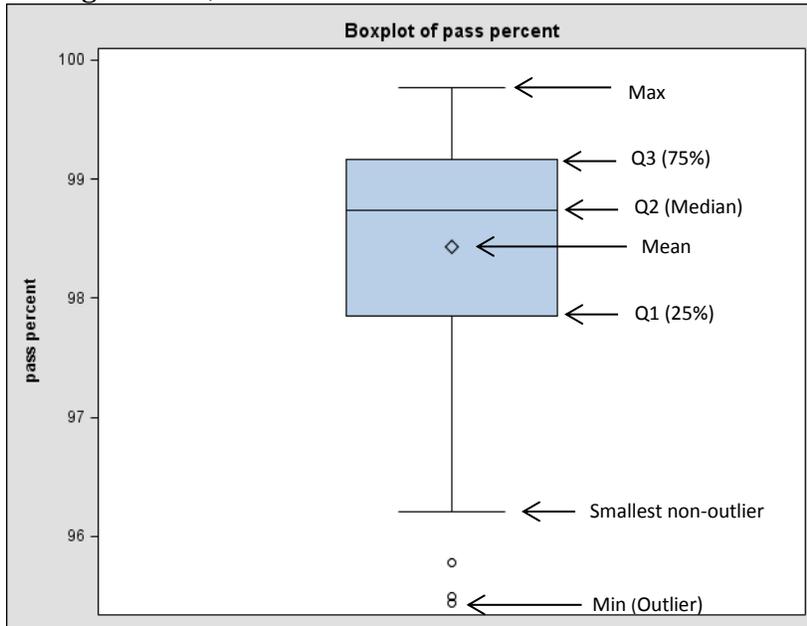
Birth Hospital Size	Total Screened	Final Screen Result					
		Pass		Fail		Incomplete	
		Number	Percent	Number	Percent	Number	Percent
Small	29,808	29,318	98.4	342	1.1	148	0.5
Small-Medium	59,126	58,203	98.4	676	1.1	247	0.4
Medium	129,631	127,659	98.5	1,460	1.1	512	0.4
Large	337,031	331,037	98.2	4,349	1.3	1,645	0.5
All hospitals	555,596	546,217	98.3	6,827	1.2	2,552	0.5

From 2009 to 2013, there were 555,596 Michigan infants among all hospital live births who received a hearing screen. Of these infants, 98.3% (n=546,217) passed the hearing screen, 1.2% (n=6,827) failed the hearing screen and 0.5% (n=2,552) had an incomplete final screen result (Table 4).

Final screen results broken down by hospital size indicated that the percent of infants with a pass ranged from 98.2-98.4%, the percent of infants with a fail ranged from 1.1-1.3%, and the percent of infants who had an incomplete final screen result ranged from 0.4-0.5% (Table 4).

The three box plots in the following pages (Figure 2, 3 and 4) show the percentage distribution of pass, fail, or incomplete final screen results broken down by hospital.

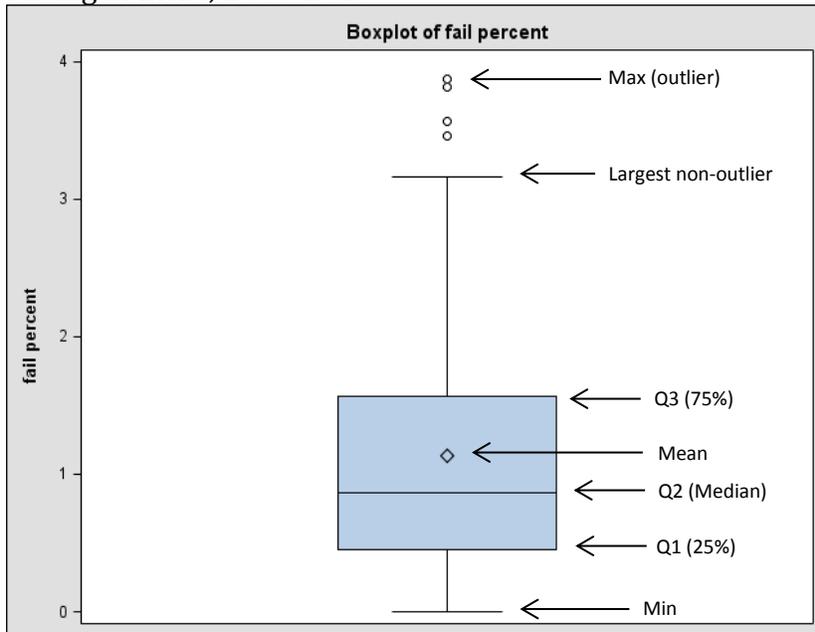
Figure 2: Percentage Distribution of Pass from Final Screen: Michigan EHDI, 2009-2013



No. of observations	84
Mean	98.4%
Median	98.7%
Minimum value	95.4%
Maximum value	99.8%

Among all birth hospitals (n=84), the percent of infants who passed the final screen ranged from 95.4% (Min) to 99.8% (Max; Figure 2).

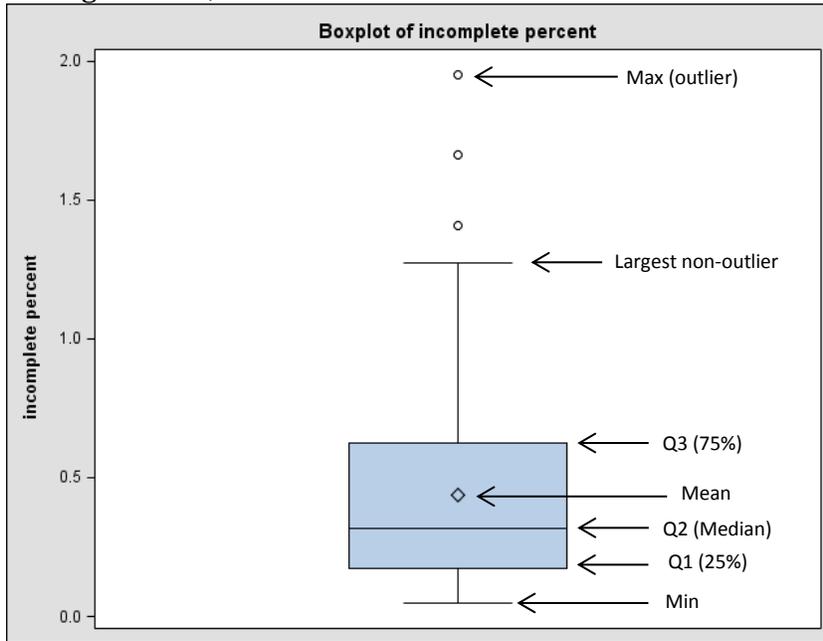
Figure 3: Percentage Distribution of Fail from Final Screen: Michigan EHDI, 2009-2013



No. of observations	84
Mean	1.1%
Median	0.9%
Minimum value	0.0%
Maximum value	3.9%

Among all birth hospitals (n=84), the percent of infants who failed the final screen ranged from 0.0% (Min) to 3.9% (Max; Figure 3).

Figure 4: Percentage Distribution of Incomplete from final screen: Michigan EHDI, 2009-2013



No. of observations	84
Mean	0.4%
Median	0.3%
Minimum value	0.04%
Maximum value	2.0%

Among all birth hospitals (n=84), the percent of infants with an incomplete final screen result ranged from 0.04% (Min) to 2.0% (Max; Figure 4).

Diagnosis and Prevalence of Hearing Loss, 2009-2013

Infants may have a diagnostic evaluation after passing or referring from the complete hearing screen, or after an incomplete screen. Table 5 gives a summary of the percent of infants with permanent and non-permanent hearing loss among those who received a diagnostic evaluation in Michigan from 2009 to 2013. Permanent hearing loss includes sensorineural, mixed, conductive permanent and auditory neuropathy types while non-permanent hearing loss includes conductive transient types. The prevalence rates of permanent and non-permanent hearing loss by the type of hearing loss are also presented within Table 5.

Table 5: Summary of Prevalence of Hearing Loss Statistics for All Hospitals: Michigan EHDI, 2009-2013

Diagnosis	Number	Percent	Rate ^a
Permanent	1,012	20.3	1.8
Sensorineural	791	15.8	1.4
Mixed	69	1.4	0.1
Conductive Permanent	100	2.0	0.2
Auditory Neuropathy	52	1.0	0.1
Non-Permanent	525	10.5	0.9
Conductive Transient	525	10.5	0.9

^aPrevalence rates are expressed over 1,000 live births

From 2009 to 2013, of 4,995 infants in Michigan who had a diagnostic evaluation, 20.3% (n=1,012) were diagnosed with permanent hearing loss and 10.5% (n=525) were diagnosed with non-permanent hearing loss (Table 5).

From 2009 to 2013, the prevalence of permanent hearing loss was 1.8 (95% CI: 0.7-1.7) cases per 1,000 live births among all hospital births in Michigan. The prevalence of non-permanent hearing loss was 0.9 (95% CI: 0.8-1.0) cases per 1,000 live births for all hospital births in Michigan (Table 5).

The prevalence of permanent and non-permanent hearing loss among hospital live births in Michigan from 2009 to 2013 was also assessed by hospital size (Table 6).

Table 6: Prevalence of Hearing Loss by Birth Hospital Size: Michigan EHDI, 2009-2013

Birth Hospital Size	Number of Live Births	Hearing Loss		Rate ^a	
		Non-Permanent	Permanent	Non-Permanent	Permanent
Small	29,964	21	37	0.7	1.2
Small-Medium	59,428	46	91	0.8	1.5
Medium	130,169	134	201	1.0	1.5
Large	337,176	324	683	1.0	2.0
All hospitals	556,737	525	1,012	0.9	1.8

^aPrevalence rates are expressed over 1,000 live births

From 2009 to 2013, the prevalence of non-permanent hearing loss in Michigan by birth hospital size ranged from 0.7 to 1.0 cases per 1,000 live births and the prevalence of permanent hearing loss ranged from 1.2 to 2.0 cases per 1,000 live births (Table 6).

Analysis by hospital revealed that the prevalence of non-permanent hearing loss ranged from 0.1 to 5.6 cases per 1,000 live births and the prevalence of permanent hearing loss ranged from 0.3 to 4.0 cases per 1,000 live births (data not shown).

Permanent Hearing Loss by Result of Final Screen and Expected Number, 2009-2013

Permanent hearing loss was analyzed by the result of final screen by birth hospital size to assess whether infants identified with hearing loss passed, failed or had an incomplete hearing screen (Table 7). Nationally, about 1 to 3 infants per 1,000 births are diagnosed with permanent hearing loss. Based on this, the actual number of infants identified with permanent hearing loss among hospital births in Michigan is compared with the number of infants expected from national experience, to have a hearing loss diagnosis (Table 7).

Table 7: Permanent Hearing Loss by Result of Final Screen and Expected Number of Infants Diagnosed: Michigan EHDI, 2009-2013

Birth Hospital Size	Final Screen Result			Permanent Hearing Loss	
	Pass	Fail	Incomplete	Total Number	Expected Number
Small	5	30	2	37	30.0-89.9
Small-Medium	18	70	3	91	59.4-178.3
Medium	42	155	4	201	130.2-390.5
Large	144	511	28	683	337.2-1,011.5
All hospitals	209	766	37	1,012	556.7-1,670.2

In Michigan, 1,012 infants were diagnosed with permanent hearing loss among hospital births from 2009 to 2013. Of these infants, about 76% (n=766) failed, about 21% (n=209) passed and about 3% (n=37) had an incomplete screen (Table 7). The percent of infants who passed the final hearing screen but were diagnosed with permanent hearing loss (21%) is considered the false negative rate. However, it is not clear if this is due to progressive or late on-set hearing loss.

From 2009 to 2013, 557 to 1,670 infants among hospital live births in Michigan were expected to have a permanent hearing loss diagnosis and the actual number of diagnosed infants (n=1,012) fell within that range (Table 7).

Permanent Hearing Loss Prevalence Trends, 2009-2013

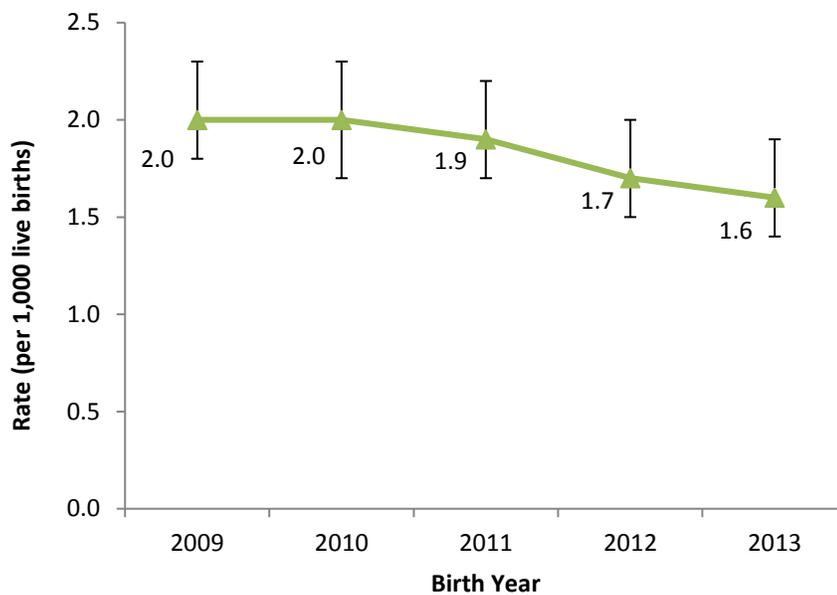
Trends in the prevalence of permanent hearing loss for all birth hospitals in Michigan from 2009 to 2013 are shown in Table 8 and Figure 5.

Table 8: Prevalence of Permanent Hearing Loss Trends for All Birth Hospitals: Michigan EHDI, 2009-2013

Birth Year	Number of infants	Rate ^a
2009	219	2.0
2010	220	2.0
2011	209	1.9
2012	188	1.7
2013	176	1.6
2009-2013	1,012	1.8

^aPrevalence rates are expressed over 1,000 live births

Figure 5: Prevalence of Permanent Hearing Loss Trends for All Birth Hospitals: Michigan EHDI, 2009-2013



The prevalence rate of permanent hearing loss among all Michigan birth hospitals from 2009 to 2013 was 1.8 (95% CI: 1.7-1.9) cases per 1,000 live births (Table 8).

Overall, among Michigan birth hospitals, the prevalence of permanent hearing loss has decreased steadily from 2.0 cases per 1,000 live births in 2009 to 1.6 cases per 1,000 live births in 2013 (Table 8 and Figure 5). This decrease in trend is statistically significant ($p=0.0103$).

Prevalence of Permanent Hearing Loss by Size of Hospital, 2009-2013

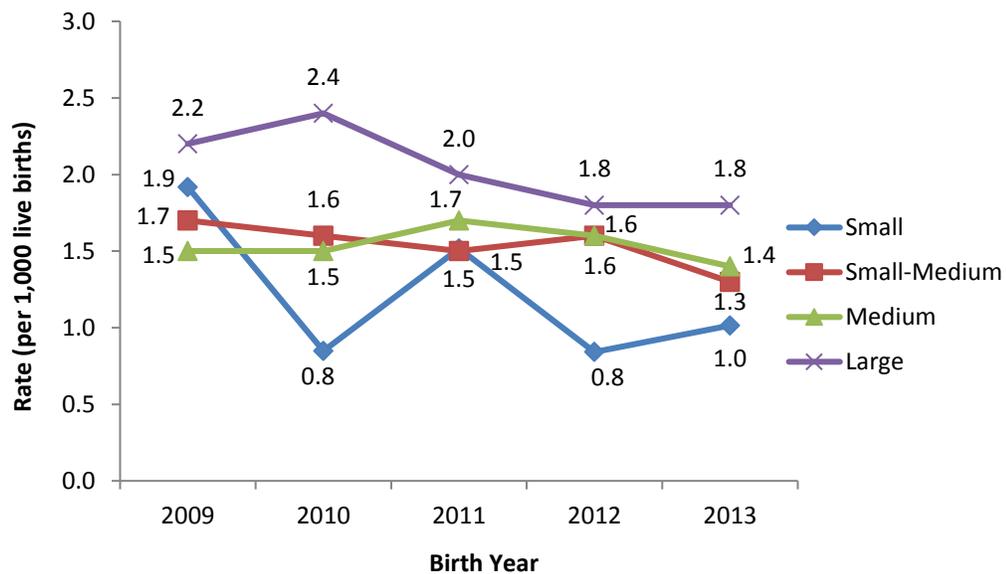
Trends in the rate of permanent hearing loss from 2009 to 2011 are analyzed by hospital size within Table 9 and Figure 6.

Table 9: Prevalence of Permanent Hearing Loss Trends by Hospital Size: Michigan EHDI, 2009-2013

Birth Year	Rate ^a			
	Size of Hospital			
	Small	Small-Medium	Medium	Large
2009	1.9	1.7	1.5	2.2
2010	0.8	1.6	1.5	2.4
2011	1.5	1.5	1.7	2.0
2012	0.8	1.6	1.6	1.8
2013	1.0	1.3	1.4	1.8
2009-2013	1.2	1.5	1.5	2.0

^aPrevalence rates are expressed over 1,000 live births

Figure 6: Prevalence of Permanent Hearing Loss Trends by Hospital Size Michigan EHDI, 2009-2013



Although the prevalence of permanent hearing loss among small hospital births has fluctuated throughout the years from 2009 to 2013, the rate has still reduced from 1.9 cases per 1,000 live births in 2009 to 1.0 cases per 1,000 live births in 2013 (Table 9 and Figure 6). Rates from 2009 to 2013 have remained relatively stable at about 1.5 cases per 1,000 live births for both small-medium and medium hospital births (Table 9 and Figure 6). Overall, the prevalence of permanent hearing loss among large hospital births has decreased slightly from 2.2 cases per 1,000 live births in 2009 to 1.8 cases per 1,000 live births in 2013 (Table 9 and Figure 6). The association between the prevalence of permanent hearing loss and hospital size was analyzed to assess whether hospital size has an effect on the prevalence of permanent hearing loss (Table 10).

Table 10: Differences in Prevalence of Permanent Hearing loss by Hospital Size: Michigan EHDI, 2009-2011

Birth Hospital Size	Difference between means	Standard Error	t-test value	p-value
Large (reference group)	1.94	0.18	10.93	<.0001
Small	-0.80	0.25	-3.21	0.0020
Small-Medium	-0.41	0.25	-1.65	0.1028
Medium	-0.40	0.25	-1.59	0.1152

This analysis indicated that overall, at least one hospital size differed significantly from another in terms of the prevalence of permanent hearing loss ($p=0.0209$). The prevalence of permanent hearing loss among small birth hospitals was significantly different than that of large birth hospitals (estimate= 0.8, $p=0.0020$, Table 10). The mean rate of permanent hearing loss among large hospital births from 2009 to 2013 was about 1.9 cases per 1,000 live births (Table 10). Compared to large birth hospitals, the mean rate difference in the prevalence of permanent hearing loss for small-medium birth hospitals (estimate=0.4, $p=0.1028$) and medium birth hospitals (estimate= 0.4, $p=0.1152$; Table 10) did not reach statistical significance. No other significant differences were found based on hospital size.

Public Health Implications

Hearing loss has significant effects on affected infants such as delay in communication, cognition, reading, and social-emotional development. Early detection and intervention is critical to maximize cognitive and communicative development in infants diagnosed with permanent hearing loss. Early and more frequent assessment is recommended for infants with risk indicators for delayed-onset hearing loss.

Our findings suggest that a statistically significant difference exists between large and small birth hospitals in terms of the prevalence of permanent hearing loss. From 2009 to 2013, the prevalence of permanent hearing loss among small birth hospitals was significantly lower than that of large birth hospitals. Suggested next steps to determine the reasons for the lower or higher hearing screen rates or the large-small hospital difference in the prevalence of permanent hearing loss may be a linkage of EHDI data with birth data to assess the impact of the transfer of infants with illness in and out of hospitals before screening occurs.

References

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