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Factors Associated with Ambulation and Transfer Ability: A Study from the National Spina Bifida Patient Registry

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Abstract

Objectives—This study used a Spina Bifida (SB) Electronic Medical Record (EMR) and the National Spina Bifida Patient Registry (NSBPR) to explore the relationship between neurosurgical/orthopedic surgeries and other variables on ambulation and transfer ability over time in individuals with SB.

Design—This study was an analysis of longitudinal data collected within the NSBPR and SB EMR. Logistic regression models were used to determine which variables were associated with ambulation/transfer ability in the myelomeningocele (MMC) and non-MMC populations.

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Results—Longitudinal data from 806 individuals were collected. In the MMC group, decreased ambulation ability was associated with higher motor levels, tethered cord releases, spine/scoliosis surgeries, hip orthopedic surgeries, and having supplemental insurance. Increased ambulatory ability was associated with lower motor levels, tibial torsion/related surgeries, ankle/foot surgeries, being female, and being non-Hispanic/Latinx. Decreased transfer ability was associated with being Hispanic/Latinx and having higher motor levels. Lower motor level and ankle/foot surgeries were associated with increased transfer ability. No significant associations were found in the non-MMC group.

Conclusions—Motor level is an important predictor of ambulation and transfer ability in MMC. Surgeries distal to the knee were associated with higher levels of function; surgeries proximal to the knee were associated with lower functional levels.

Keywords

Myelomeningocele; Rehabilitation; Spina Bifida; Spinal Dysraphism; Walking; Wheelchair; Registries

Introduction

Spina Bifida (SB) is a neural tube defect that results in incomplete closure of the neural tube during development. Annually, roughly 1,645 newborns with SB in the U.S. are delivered[1]. Despite significant health issues, at least 75% of individuals with SB are now expected to be living into adulthood due to new medical treatments, surgeries, and rehabilitation interventions[2]. Rehabilitation management of people with SB includes maximizing independence at home and in the community, along with minimizing progression of secondary conditions like orthopedic deformities.

Spinal nerve root lesions in SB can result in varying degrees of sensory loss and paralysis, which can affect an individual's ambulation ability and transfer ability. Challenges to mobility include partial or complete paralysis of lower limbs and/or trunk muscles, loss of sensation, and orthopedic deformities of the spine or lower limbs. Among other variables, independence in mobility is an important contributor to quality of life and daily life activities in individuals with myelomeningocele (MMC)[3].

Within the MMC population, neurological and orthopedic conditions are common and include tethered cord syndrome, hydrocephalus, scoliosis and other spinal deformities, hip subluxation/dislocation, and foot and ankle deformities[4]. In a cross-sectional study of children with MMC, Bartonek and Saraste showed that ambulation ability is associated with functional motor level, number of shunt revisions, spasticity in the knee and hip joints, and balance impairments[5]. Asher and Olson found a significant association between ambulation ability and motor level, obesity, and orthopedic deformities[6]. The literature on independent transfer ability within the SB population, however, is sparse. It has been demonstrated that individuals with SB and a lesion level below L2, regardless of hydrocephalus history, were likely to be independent in transfers[7]. Approximately 38% of SB individuals with hydrocephalus and a lesion level above L2 require help with transfers[7].

The National Spina Bifida Patient Registry (NSBPR) was formed through a cooperative agreement between the Centers for Disease Control and Prevention and the Spina Bifida Association. The NSBPR now includes 20 sites across the United States that record extensive medical, surgical, and functional data on over 10,000 individuals with SB[8]. Studies that used the NSBPR have shown that in patients with all types of SB, no history of a shunt for hydrocephalus, lower motor level, and no history of hip or knee contracture release surgery are associated with higher ambulation ability, regardless of SB type[9]. In those with MMC, changes in motor level that result in more weakness reduce the odds of independent ambulation over time, but this effect becomes insignificant with increasing age[10]. In those with MMC, the number of orthopedic surgeries and neurosurgeries (including shunts) also reduce the odds of independent ambulation over time, especially for those with lower motor levels[10]. Motor level is the predominant factor associated with baseline transfer ability, with age also contributing to a lesser degree. Additionally, a change in transfer ability over time is associated with a corresponding change in motor level[11].

However, what is not known is the extent to which all neurosurgeries and orthopedic surgeries that a person has had over a lifetime contribute to ambulation and transfer ability. For instance, the NSBPR does not contain a full history of all orthopedic surgeries of the hip, knee, tibia, or foot. While it captures all shunt placements, it does not capture the exact number of all shunt revisions. A specialized electronic medical record (EMR) accompanies the NSBPR and can be used by clinics to collect the neurosurgical and orthopedic surgeries not in the NSBPR. The aim of this study was to determine which additional neurosurgical or orthopedic surgery variables captured in the EMR contribute significantly to ambulation and transfer ability in individuals with SB over time and whether motor level retains its strong predictive association with these outcomes.

Methods

All data in this study were collected using oversight from each participating institution's Institutional Review Board-approved protocols. All data were collected using a software system called WebTracker. This software system is comprised of two components: The NSBPR and a full SB EMR. The NSBPR is a secure database that contains crucial variables including: subtype of SB, shunt placement for hydrocephalus, motor level, ambulatory status, and other variables related to SB[12]. The NSBPR is connected to an EMR that is made specifically for individuals with SB. This EMR allows for additional variables to be collected that are not otherwise part of the NSBPR, including additional neurosurgeries (e.g., shunt revisions) and orthopedic surgeries (e.g., hip, knee, tibia, foot). These additional variables were collected in the EMR at The Pediatric Spina Bifida Clinic at Children's Hospital of Pittsburgh of the University of Pittsburgh Medical Center (UPMC), the UPMC Adult Spina Bifida Clinic, and Pediatric Spina Bifida Clinic at The Children's Hospital of Colorado. This study conforms to all STROBE guidelines and reports the required information accordingly (see Supplementary Checklist).

Inclusion criteria were:

- A diagnosis of:

1. Myelomeningocele
2. Meningocele
3. Lipomyelomeningocele (Lipoma of Spinal Cord)
4. Fatty/Thickened Filum
5. Terminal Myelocystocele
6. Split Cord Malformation

- Written informed consent of adult participants who were their own medical power of attorney must have been obtained; a parent, guardian, or medical power of attorney must have given written informed consent by proxy if the subject was a child or was unable to make his or her own medical decisions.

Exclusion criterion was a diagnosis of any other type of spinal dysraphism. Data from individuals age 5 years and younger were excluded from analysis because manual muscle testing is not reliable in those under the age of 5[3].

The following demographics were collected: age at each visit (treated as an ordinal variable), gender (male/female), ethnicity (Hispanic/Latinx or non-Hispanic/Latinx), race (9 categories), subtype of SB (myelomeningocele, meningocele, lipomyelomeingocele, fatty/thickened filum, terminal myelocystocele, or split cord malformation) and type of insurance (any private, public only, supplemental with or without public insurance, or uninsured).

Additionally, the following functional and surgical variables were recorded:

- Functional level of lesion, as defined by the NSBPR[13]. (Figure 1)
  - *If impairment differed from side to side, the side with greater impairment was used to determine overall functional level of lesion
- Ambulatory status, which was defined in the NSBPR using a four-level scale published by Hoffer [14]. (Figure 2)
- Transfer ability was defined in the NSBPR as the ability to transfer from a wheelchair to another level surface (independent, totally dependent, or requires some assistance)[11]. This was applicable only to those who use wheelchairs (therapeutic or non-ambulators on the Hoffer scale[14])

Neurosurgeries were classified into the following binary categories (yes/no), unless otherwise stated:

- History of cerebral shunt placement or endoscopic third ventriculostomy (ETV): used as a proxy measure of hydrocephalus
- Number of cerebral shunt revisions (ordinal): all shunt surgeries (e.g., revisions, replacements, removals, etc.) excluding the initial placement
- History of Chiari II malformation decompression
- History of tethered cord release

- History of shunting for syringomyelia
- History of cerebral shunt revisions/modifications
- History of external ventricular drain (EVD) placements

Orthopedic surgeries were classified into the following binary categories (yes/no) based on the anatomic area affected:

- History of spine or scoliosis surgery
- History of hip surgery
- History of knee surgery
- History of tibial torsion and related surgeries
- History of ankle/foot surgery

In order to examine the effect of shunt revisions and associated factors on ambulation and transfer ability, binary logistic models were developed using SAS v. 9.4. Individual logistic regression models were created for ambulation ability and transfer ability for both MMC and non-MMC subtypes, including the above referenced variables as model inputs. A time variable was created to reflect the length of time an individual was followed by the registry, as indicated by number of annual visits (treated as an ordinal variable). This time variable allowed for longitudinal analysis of the data to determine which factors were associated with ambulation and transfer ability "over time." Ambulation ability was collapsed into a binary measure: independent ("community ambulators" or "household ambulators") and dependent/non-ambulators ("therapeutic ambulators" or "non-ambulators"). Transfer ability was also collapsed into a binary measure: independent ("independent transfers") and dependent ("totally dependent transfers" or "requires some assistance with transfers").

Overall model fit statistics, which measures how similar a model's predicted values are to observed data, were examined. A likelihood ratio chi-square and related p-value demonstrated that the model for MMC as a whole (e.g., motor level, number of shunt revisions, etc.) predicts ambulation status and transfer ability significantly better than an empty model (i.e., no predictors). The overall effect of each of the predictors was examined using Type III maximum likelihood estimates. Finally, the estimates, their standard errors, the Wald Chi-Square statistic, and associated p-values were examined. The logistic regression odds ratio point estimates represent a relative measure of effect size (e.g., a particular surgery is associated with a higher likelihood of independent ambulation or transfer ability as compared to another surgery with lower odds ratio).

Results

In total, 643 individuals with MMC and 163 individuals with non-MMC seen between 5/5/2009 and 5/21/2019 contained complete records and were included in the analysis. Demographics are listed in Table 1. In total, 528 out of 643 individuals in the MMC group had a history of shunt placement, with 268 of these individuals being independent ambulators, and 260 being dependent ambulators. The median number of shunt revisions for independent ambulators was 1 (range 0–26), for dependent ambulators was 2 (range 0 to 29), and for all shunted individuals, regardless of ambulation status, was 2 (range 0 to 29).

MMC – Ambulation Ability

For the MMC group, the combination of a history of any shunt revision, age, race, ethnicity, insurance status, motor level, and surgical history was significantly associated with ambulation ability over time (Wald $\chi 2(31) = 1025.0$, $p<.001$). (Table 2). This combination of predictors resulted in a strong model fit (Somer's D=0.885). A ROC curve was created, and resulted in a very strong area under the curve value of 0.946. The following variables were associated with decreased independent ambulation ability over time as reflected by statistically significant odds-ratio parameter estimates: a higher motor level (thoracic: p<.001, odds ratio <0.001, high-lumbar: p<.001, <0.001), having supplemental insurance with or without public insurance (p=.002, 0.167), a history of spine/scoliosis surgery (p<.001, 0.172), a history of hip surgery (p=.011, 0.280), and a history of tethered cord release (p=.003, 0.379). Increasing numbers of annual visits were associated with decreased independent ambulation over time, however, the association was weak (p<.001, 0.903). The following were associated with increased independent ambulation ability over time in the MMC group: a lower motor level (mid-lumbar: p<.001, 0.025, low-lumbar: p<.001, 0.106), being non-Hispanic/Latinx (p=.002, 392.8), having a history of tibial torsion or related surgeries (p=.030, 0.956), a history of ankle/foot surgery (p=.024, 0.617), and being female (p<.001, 2.059). Older age was associated with increased independent ambulation ability over time, but the association was weak (p<.001, 1.034). The remaining independent input variables were not statistically significant.

MMC- Independent Transfer Ability

In the MMC group, the combination of a history of any shunt revision, age, race, ethnicity, insurance status, motor level, and surgical history was significantly associated with transfer ability over time (Wald $\chi 2$ (30) = 190.11, $p<.001$). (Table 3). This combination of predictors resulted in an acceptable model fit (Somer's D=0.468). A ROC curve was created, and resulted in a moderately strong area under the curve value of 0.763. The following was associated with decreased independent transfer ability over time: being Hispanic/Latinx (p<.001, 0.098) and a higher motor level (thoracic: p<.001, 0.936, high-lumbar: p=.036, 1.314). Lower motor level (mid-lumbar: p=.006, 2.987) and having a history of ankle/foot surgery (p=.045, 0.757) were associated with increased independent transfer over time. Increasing numbers of annual visits (p<.001, 1.072) and older ages (p<.001, 1.031) were both associated with increased independent transfer ability over time, but the association was weak. The remaining independent variables were not statistically significant.

Non-MMC Ambulation Ability and Independent Transfer Ability

In the non-MMC group, none of the previously examined variables (e.g., age, motor level, ethnicity, etc.) were significantly associated with ambulation or independent transfer ability over time.

Discussion

This study was, to our knowledge, the first to use an EMR built for individuals with SB to examine the relationship between a complete history of neurosurgeries and orthopedic surgeries and ambulation and transfer ability over time. It therefore expands upon previous cross-sectional[5, 9] and longitudinal studies [10, 11] due to the addition of these neurosurgical and orthopedic surgery variables into the prediction models.

Motor level was a strong predictor of ambulation ability and transfer ability over time. However, this was true only for the MMC population. This confirms findings in prior work[9–11] but also builds upon it by demonstrating that motor level continues to be a more important predictor than many neurosurgical or orthopedic surgery variables. The small sample size of the non-MMC group, combined with less variability in motor level (i.e., 63.8% of individuals exhibited a sacral motor level) and ambulation status (87.8% community ambulators), may have limited our ability to detect motor level as a predictor of ambulation and transfer ability in this group.

The number of shunt revisions was not a significant predictor of ambulation and transfer ability. The percentage of individuals with MMC in our study with a prior history of a shunt was similar to the percentages reported in other studies (80.0% to 86.4%) [9, 15, 16]. However, in our study, the median number of shunt revisions in independent ambulators was similar to that of dependent ambulators. Thus, the number of shunt revisions may not be a reliable proxy measure for ambulation or transfer ability.

Increased ambulation ability was associated with surgeries distal to the knee (tibia and ankle/foot), while decreased ambulation ability was associated with surgeries proximal to the knee (tethered cord release, spine/scoliosis, and hip.). Increased transfer ability was associated with ankle/foot surgery. Causation cannot be assumed here. Surgeries are often performed to preserve function or halt decline and therefore may be a proxy measure of the severity of the individual’s condition or motor level. For example, surgery to correct a foot or ankle deformity may be done to preserve ambulation ability in an individual with a high likelihood of long-term walking ability, whereas scoliosis surgery may be performed to preserve pulmonary function or correct posture in someone who primarily uses a wheelchair. The NSBPR does not collect information about the presence of some orthopedic (e.g., scoliosis, hip dysplasia) or neurosurgical issues (e.g., tethered cord syndrome) unless the patients undergo surgery for those conditions. An opportunity therefore exists to expand the registry with these variables so that we can more fully understand the impact of surgery on functional outcomes.

Additionally, older age was a weak predictor for both increased ambulation ability and increased transfer ability over time. This result may be due to survival bias, as older individuals may represent those with less severe conditions (e.g., lower level of lesion or no hydrocephalus) who were more likely to survive to older ages.

Several other sociodemographic factors were found to have significant associations with ambulation or transfer ability, namely insurance status, ethnicity, and gender. Race contributed to a strong fit of both models. Our study was neither designed nor powered to thoroughly explore the effects of these factors. However, this finding points to the need for future research to understand how sociodemographic factors can affect functional outcomes.

Several limitations of our study deserve discussion. First, although the NSBPR is the largest registry of patients with SB, it is comprised of multidisciplinary clinics located primarily at academic centers and only a subset collects the array of EMR data of interest in this study. This may limit generalizability of the results to the population as a whole. It is estimated that over half of adults with SB receive care in states without clinics that participate in the NSBPR[17]. Across all sites in the NSBPR, those who are eligible to enroll in the NSBPR, but do not enroll, tend to have the non-MMC subtype, be younger, and be non-Hispanic/Latinx, which may have introduced enrollment bias. Second, some variables such as motor level may have low inter-rater reliability[18]. However, the clinics participating in the NSBPR follow quality control processes to mitigate bias in data collection procedures as much as possible. Previous work has shown that the motor level tool used in the NSBPR is significantly correlated with ambulation ability even when strength ratings between examiners may vary between 1 to 3 on manual muscle test grading[13]. Third, we did not account for the timing of surgeries in the model because the dates of many surgeries were not known, especially for older adults. Additionally, several of our significant parameter estimates, such as supplemental insurance, have very few cases. Future work is needed to determine if early interventions have a different relationship with outcomes. Finally, we did not incorporate obesity as an independent variable. Obesity is difficult to measure in this population due to complex anthropometrics. Multi-site collaborative research is currently underway to establish standardized measures of obesity[19–21].

Conclusion

To our knowledge, this is the first study to examine the contribution of a full neurosurgical and orthopedic surgery history to ambulation and transfer ability in SB over time. Motor level continues to be an important predictor of both ambulation and transfer ability. Surgeries distal to the knee were associated with higher levels of function, while surgeries proximal to the knee were associated with lower functional levels. These results may be able to help clinicians inform patients and families about variables that impact functional prognosis.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What is Known:

Previous studies have evaluated the relationship between ambulation ability and a limited set of surgical variables.

What is New:

To our knowledge, this is the first study to examine the relationship between a complete orthopedic and neurological surgery history and ambulation and transfer ability in individuals with Spina Bifida over time.

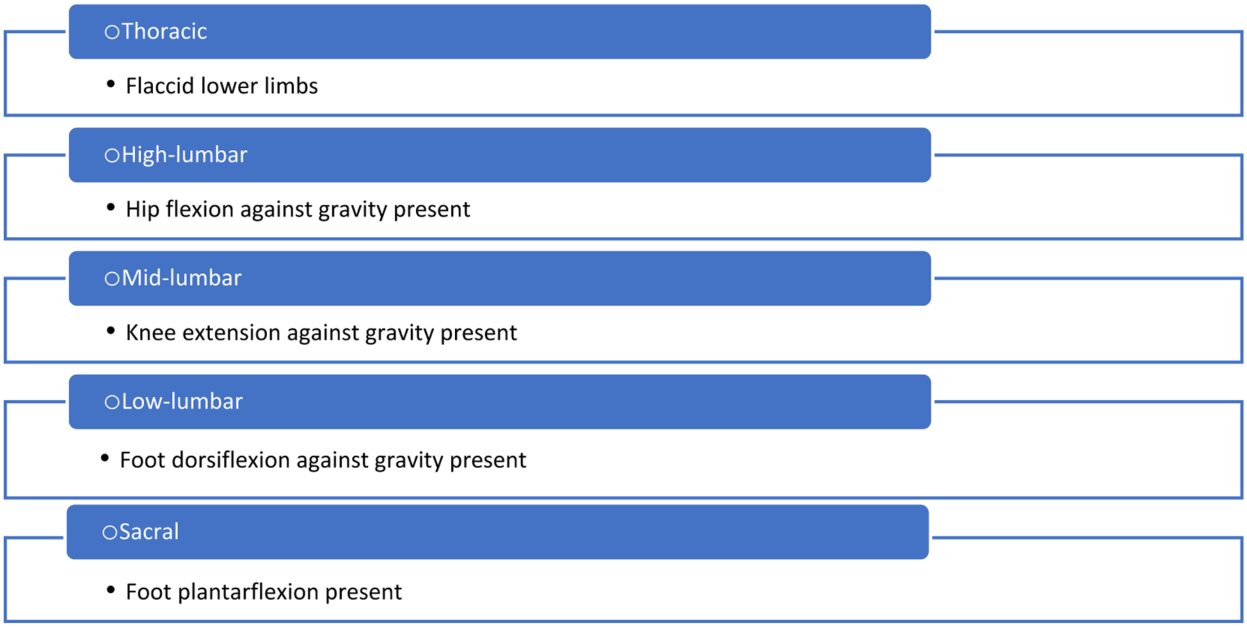

Figure 1:
Functional level of lesion definitions.

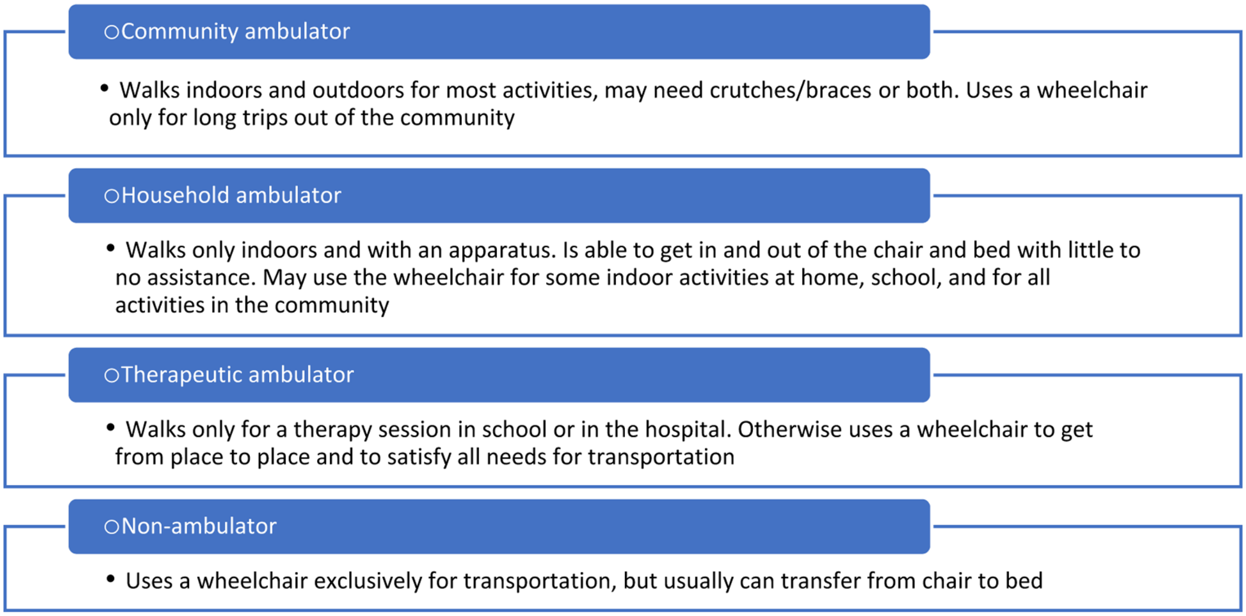

Figure 2:
Hoffer classification of ambulatory status.

Table 1:

Demographics.

	MMC (n = 643)	%	Non-MMC (n = 163)	%
Average Age (Range)	20.8 (5–88)	n/a	21.7 (5–80)	n/a
Gender				
Female	321	49.9	96	58.9
Male	322	50.1	67	41.1
Ethnicity				
Non-Hispanic/Latinx	540	84.0	137	84.0
Hispanic/Latinx	98	15.2	26	16.0
Refused	5	0.8	0	0.0
Race				
White	568	88.3	140	85.9
African American	21	3.3	2	1.2
Asian	18	2.8	12	7.4
Multi-Racial	17	2.6	3	1.8
Other	11	1.7	5	3.1
Unknown	5	0.8	0	0.0
Refused	2	0.3	0	0.0
American Indian/Alaskan Native	0	0.0	1	0.6
Native Pacific/Hawaiian	1	0.2	0	0.0
Insurance				
Private	305	47.4	100	61.3
Public Only	319	49.6	61	37.4
Supplemental with or without Public	12	1.9	2	1.2
Uninsured	7	1.1	0	0.0
Functional Level of Lesion				
Thoracic	171	26.6	6	3.7
High-Lumbar	55	8.6	5	3.1
Mid-Lumbar	236	36.7	35	21.5
Low-Lumbar	62	9.6	13	8.0
Sacral	119	18.5	104	63.8
Ambulation Status				
Community	287	44.6	143	87.8
Household	63	9.8	7	4.3
Therapeutic	37	5.8	1	0.6
Non-Ambulatory	256	39.8	12	7.4
Transfer Status				
Independent	173	64.3*	7	58.3*
Totally Dependent	55	20.4*	4	33.3*
Requires Some Assistance	41	15.2*	1	8.3*

*Indicates percentages are out of total respondents to question.

Table 2:

Analysis of Maximum likelihood analysis for independent ambulation ability in individuals with MMC.

	Parameter	Odds Ratio	95% CI	Standard Error	Wald Chi-Square	P value
	Intercept			179.90	0	.976
	Increasing Number of Shunt Revisions	1.032	1.014–1.050	0.01	3.74	.053
	Number of Annual Visits	0.903	0.860–0.949	0.03	15.36	<.001 *
	Age	1.034	1.024–1.043	0.01	73.70	<.001 *
Gender						
	Female	2.059	1.698–2.497	0.06	41.73	<.001 *
Race						
	Asian	0.059	0.005–0.756	179.90	0	.992
	African -American	0.148	0.012–1.826	179.90	0	.984
	Multi-Racial	0.067	0.005–0.825	179.90	0	.988
	Other	0.018	0.001–0.247	179.90	0	.996
	White	0.084	0.007–0.995	179.90	0	.986
	Refused	<0.001	<0.001–>999.9	375.40	0	.979
	Pacific/Native-Hawaiian	<0.001	<0.001–>999.9	1215.30	0	.996
Ethnicity						
	Hispanic or Latinx	179.14	8.854–>999.9	0.62	1.28	.258
	Not Hispanic or Latinx	392.8	19.617–>999.9	0.61	9.60	.002 *
Insurance						
	Any Private	0.420	0.171–1.033	0.19	0	.953
	Public Only	0.519	0.213–1.267	0.18	3.80	.051
	Supplemental with or without Public	0.167	0.055–0.510	0.37	9.55	.002 *
Motor Level						
	Thoracic	<0.001	<0.001–<0.001	0.20	540.74	<.001 *
	High-Lumbar	<0.001	<0.001–0.002	0.18	240.66	<.001 *
	Mid-Lumbar	0.025	0.013–0.050	0.12	73.03	<.001 *
	Low-Lumbar	0.106	0.050–0.226	0.20	145.32	<.001 *
Neurosurgical History						
	History of Chiari II Malformation Decompression	0.230	0.059–0.899	0.33	1.58	.208
	History of Shunting for Syringomyelia	0.568	0.142–2.267	0.36	0.05	.830
	History of Shunt Placement/ETV [1]	0.448	0.134–1.501	0.15	1.33	.249
	History of Tethered Cord Release	0.379	0.112–1.284	0.20	9.13	.003 *

	Parameter	Odds Ratio	95% CI	Standard Error	Wald Chi-Square	P value
	History of Shunt Revisions/ Modifications	0.432	0.130–1.435	0.14	0.99	.321
	History of EVD[2] Placement	0.492	0.135–1.789	0.26	1.60	.206
Orthopedic Surgical History						
	History of Ankle/Foot Surgery	0.617	0.183–2.080	0.17	5.10	.024 *
	History of Knee Surgery	0.351	0.086–1.435	0.41	0.97	.325
	History of Spine/Scoliosis Surgery	0.172	0.047–0.630	0.31	13.29	<.001 *
	History of Hip Surgery	0.280	0.079–0.998	0.25	6.40	.011 *
	History of Tibial Torsion and Related Surgeries	0.956	0.235–3.898	0.37	4.73	.030 *

* Indicates the variable is of statistical significance at the $p<.05$ level.

** Some races not represented due to missing ambulation data.

[1] Endoscopic Third Ventriculostomy.

[2] External Ventricular Drain.

Table 3:

Analysis of Maximum likelihood analysis for independent transfer ability in individuals with MMC.

	Parameter	Odds Ratio	95% CI	Standard Error	Wald Chi-Square	P value
	Intercept			187.20	0	.979
	Increasing Number of Shunt Revisions	1.031	1.010–1.052	0.01	0.41	.524
	Number of Annual Visits	1.072	1.004–1.146	0.03	12.05	<.001[*]
	Age	1.031	1.020–1.042	0.01	79.01	<.001[*]
Gender						
	Female	0.736	0.581–0.932	0.06	0.02	.876
Race						
	Asian	>999.9	<0.001->999.9	265.10	0	.963
	African-American	33.89	2.942–390.5	44.18	0	.989
	Multi-Racial	27.09	2.309–318.0	44.18	0	.999
	Other	76.02	5.462->999.9	44.19	0	.999
	White	8.670	0.840–89.51	44.18	0	.975
	Refused	0.147	0.012–1.767	44.20	0.03	.875
Ethnicity						
	Hispanic or Latinx	0.098	0.018–0.530	0.40	12.83	<.001[*]
	Not Hispanic or Latinx	0.174	0.034–0.902	0.39	2.90	.089
Insurance						
	Any Private	<0.001	<0.001->999.9	181.90	0	.985
	Public Only	<0.001	<0.001->999.9	181.90	0	.985
	Supplemental with or without Public	<0.001	<0.001->999.9	181.90	0	.982
Motor Level						
	Thoracic	0.936	0.174–5.036	0.25	16.00	<.001[*]
	High-Lumbar	1.314	0.240–7.183	0.26	4.38	.036[*]
	Mid-Lumbar	2.987	0.552–16.17	0.26	7.60	.006[*]
	Low-Lumbar	4.390	0.586–32.86	0.58	3.47	.062
Neurosurgical History						
	History of Chiari II Malformation Decompression	0.398	0.088–1.795	0.31	2.64	.104
	History of Shunting for Syringomyelia	0.408	0.066–2.528	0.60	0.22	.638
	History of Shunt Placement/ETV[1]	0.566	0.140–2.289	0.18	0.03	.855
	History of Tethered Cord Release	0.655	0.159–2.694	0.22	0.09	.770
	History of Shunt Revisions/ Modifications	0.499	0.124–1.998	0.16	0.68	.411
	History of EVD[2] Placement	0.389	0.085–1.776	0.31	0.91	.342

	Parameter	Odds Ratio	95% CI	Standard Error	Wald Chi-Square	P value
Orthopedic Surgical History						
	History of Ankle/Foot Surgery	0.757	0.183–3.125	0.22	4.01	.045 *
	History of Knee Surgery	0.305	0.063–1.469	0.41	3.19	.074
	History of Spine/Scoliosis Surgery	0.543	0.131–2.245	0.22	0	.984
	History of Hip Surgery	0.780	0.185–3.289	0.23	0.82	.365
	History of Tibial Torsion and Related Surgeries	0.684	0.129–3.638	0.46	0.13	.714

*Indicates the variable is of statistical significance at the p<.05 level.

**Some races not represented due to missing transfer data.

[1]Endoscopic Third Ventriculostomy.

[2]External Ventricular Drain.