

Risk Assessment of Neurological and/or Vertebrobasilar Complications in the Pediatric Chiropractic Patient

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Abstract — Reports suggest that chiropractic accounts for a large percentage of visits to alternative health practitioners. Moreover, pediatric patients represent a significant proportion of these visits. In light of this trend, it is important to evaluate the risk potential to the pediatric patient presenting for chiropractic care. This paper has reviewed literature concerning the occurrence of neurological and/or vertebrobasilar (N/VB) complications in patients receiving either specific chiropractic adjustments and/or non-specific manipulations of the spine. This topic was chosen due to the potentially severe consequences of N/VB complications, regardless of etiology. The current study was conducted in a quasi-meta analysis format to derive data for the period encompassing 1977 through the first quarter of 1998, using an eclectic compilation of data from three survey sources. Based on this information, the number of pediatric visits, extrapolated to also include the periods between 1966 and 1977, was estimated to be 502,184,156. Reports of the occurrence of N/VB complications in chiropractic pediatric patients were also investigated over the same time period by searching the scientific/clinical literature. The estimate of risk due to the pediatric chiropractic patient in this category of complication was estimated to be $4.0 \times 10^{-7}\%$ of all visits. Stated otherwise, there would be a chance of approximately 1 in 250 million pediatric visits that a N/VB complication would result. While some pre-existing conditions may predispose a pediatric patient to a higher incidence of such complications, the estimates derived in the present study are considered applicable to the general pediatric population. The estimates derived in the present study are intended to be an initial risk assessment. Since very few reports exist relative to the incidence of N/VB complications in children, additional studies will be necessary to confirm this risk estimate.

Key Words: adjustment, child, children, chiropractic, complication, injury, manipulation, neural complication, risks, neurological incident, vertebrobasilar incident.

Introduction

The objective of the present paper has been to create a starting point from which to evaluate the specific risk factors associated with neurological and/or vertebrobasilar (N/VB) complications in pediatric patients receiving chiropractic care. Presently, the chiropractic profession is woefully lacking in the self-assess-

ment data required to derive such estimates. For example, there is no solicitation of periodic reports of morbidity or mortality statistics from chiropractic practitioners relative to patients under 18 years of age, even though there is a strong interest in chiropractic pediatric care.¹ Additionally, there is no mechanism in operation designed to accurately ascertain the number of visits to chiropractors by juveniles, regionally, nationally or globally.

Kent has noted that there exists no current data regarding the total number of cervical adjustments and/or manipulations performed annually, or the total number of complications.² Both of these figures are necessary to specifically assess risks. Kent has also noted that there have been no scientific studies that adequately control for other risk factors associated with neurological complications and/or vertebrobasilar incidents. It is apparent that this information will have to be forthcoming to most accurately assess the risk of complications occurring in the pediatric population under chiropractic care.

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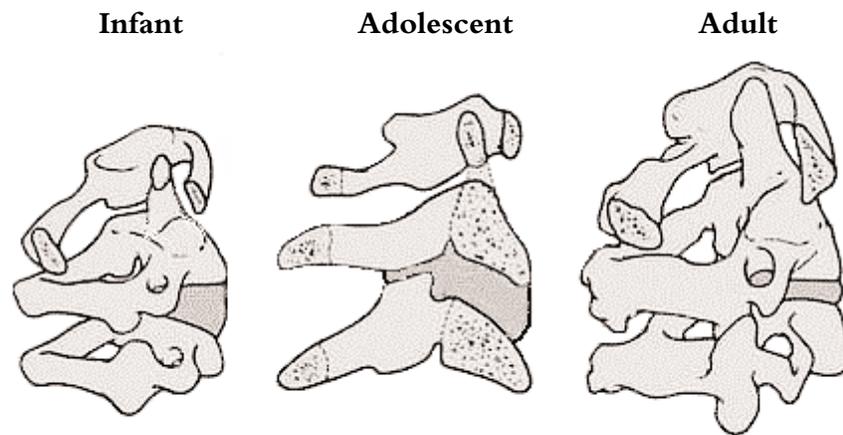


Figure 1. This drawing illustrates the relative angulations of facets, and development of joints of Luschka during various stages of maturation.

Without a serious effort to characterize the profession relative to these factors, it will remain speculative at best to derive numerical values representing risk. In recognition of the present limitations to such an endeavor, the current study was undertaken as an initial effort to provoke more interest in this issue, and to create a basis for future evaluation of the risks associated with pediatric chiropractic care. Although a number of risk factors could be considered, N/VB risk was selected for the present study due to the potential severity of complications associated with such an incident. Moreover, because of the potential danger to the pediatric patient, it was deemed likely that if this type of complication occurred, it would be readily reported in the scientific/clinical literature.

Since chiropractic often involves cervical adjustments, ranging from very low to moderate force, the concern for N/VB complications must be assessed, especially in the pediatric population. In this regard, most complications following cervical manipulation are due to disturbances of vertebral artery circulation, and the resultant ischemic damage to neurological components supplied by the vertebrobasilar system.³ Although it has been reported that vertebral artery dissection is an uncommon cause for stroke in children,⁴ current statistics reveal that the pediatric population is not exempt from this phenomenon. Reports show the annual incidence of strokes for children under 15 years of age, from all causes, to be 2.7 per 100,000 children.⁵

There is a strong correlation between the severity of spinal cord injury and the immaturity of the spine.⁶ Thus, it behooves the chiropractic profession to pay special attention to avoiding procedures that could induce stroke or other related complications in the pediatric patient, since the majority of complications attributed to spinal manipulative procedures are related to rotational manipulation of the cervical spine.⁷ This is significant when considering that the spine in the first decade of life is characterized by facets with shallow angulations, immature joints of Luschka, osseoligamentous structures that are lax, and cervical musculature that is immature in regard to strength.⁸ The essentially wedge-shaped vertebral bodies are prone to slippage between adjacent vertebrae because the facets are aligned horizontally, becoming vertical only with maturity (Figure 1). After the first decade of life, the spine gradually takes on the characteristics of the adult spine.

According to Webster, to minimize risk to the pediatric patient, all spinal adjustments should be of very low force and short amplitude.⁹ To this end, Schmitt suggests a change from manipulative methods, including any violent movements, to low force movements, which will help to minimize vascular complications.¹⁰ Webster also states that due to the lack of facet development rotational forces should not be used in pediatric adjusting procedures; all spinal adjustments in the pediatric patient should be performed in straight posterior to anterior or straight lateral to medial lines of correction. Additionally, Webster notes that vertebral contact points should only include primary centers of spinal ossification. In consideration of these complications reported in association with pediatric chiropractic care, it appears evident that adjusting procedures for the pediatric patient should exclude any maneuver that includes rotation, extension, and traction.⁹ It is anticipated that chiropractic practitioners, if not already doing so, will heed these cautions.

Reports of serious complications regardless of age, following chiropractic adjustments and/or manipulation, are extremely rare.¹¹⁻¹³ Nevertheless, since disturbance of vertebral artery circulation is the most commonly reported adverse event associated with the adult population under chiropractic care, the present study has focused on evaluating the risk of occurrence of neurological and/or vertebrobasilar complications in the pediatric patient.

Risk assessment is also an important issue relative to the increasing utilization of complementary/alternative medicine, into which chiropractic has been grouped in the literature. Eisenberg et al.,¹⁴ have suggested that in 1990 as many as 425 million visits were made to providers of "unconventional therapy," exceeding the estimate of 388 million visits to all U.S. primary care (medical) physicians. Moreover, these authors also estimated that as many as 16,000,000 Americans utilized at least one of the 16 "unconventional therapies" evaluated, which included chiropractic.

While these numbers relate to adults (18 years or older), a 1994 study by Spiegelblatt, et al.,¹⁵ evaluated 1,911 responses from a self-administered questionnaire to parents of children visiting a university outpatient clinic in Quebec, Canada, relative to pediatric use of alternative medicine. Questionnaire analysis revealed that respondents matched the ethnic origin and level of

education of Montreal. The respondents also reflected similar sociodemographics of previous studies by the Quebec Government (OPQ survey)¹⁶ designed to evaluate the use of alternative medicine, suggesting that the results could be extrapolated to represent the overall population. Notable among the findings by Spiegelblatt et al. was that 11% of children of respondents had previously visited "alternative medicine practitioners." Of the 11%, the largest number (37%) visited chiropractors. Based on the 1991 census of Quebec,¹⁷ there were 1,157,112 children in Quebec. This suggests that possibly as many as 47,094 children were likely to be visiting chiropractors at the time of the study. Based on a conservative estimate of five visits/child/year, it is reasonable to presume that approximately 235,470 pediatric visits could have occurred in Quebec, as a reflection of the Spiegelblatt, et al. study. Although the present study is restricted to evaluating the potential N/VB risk relative to pediatric chiropractic visits in the United States, it is apparent from the information available from other countries such as Great Britain, Australia, and New Zealand, that a considerable number of children annually visit a chiropractor.

It is also important to recognize that the benefits arising from chiropractic care must be weighed against any potential risk. For example, in one study, 73% of the parents of "sick" children reported that chiropractic care had been of benefit to their child.¹⁸ As well, children under chiropractic care have also been shown to demonstrate measurable improvement in conditions ranging from respiratory dysfunction¹⁹⁻²¹, enuresis²²⁻²⁴, and other problems.²⁵⁻²⁷ Consequently, based on the substantial numbers of visits to chiropractors by pediatric patients, as well as the benefits reported in the literature, it is necessary to estimate the potential risk of complications to pediatric patients presenting for chiropractic care, in assessing the risk/benefit ratio.

Methods

Sources

This investigation has utilized information primarily from three sources in a quasi meta-analysis format, which lacks the statistical comparisons suggested by Wolf.²⁸ Statistical assessment was not possible due to the nature of the studies from which the data was drawn. For example, surveys by the Department of Health and Human Resources, and the American Chiropractic Association, as of 1990, did not consider the ramifications of response rate, reporting the actual number of survey instruments mailed, sociodemographics of the respondents versus non-respondents, validation of the questionnaire itself, and other factors, all of which impact on the validity of the results. However, these surveys represented the only forms of data collection at those particular times. In spite of the limitations, this approach was chosen in order to obtain sufficient data to construct a conservative estimate of the number of pediatric visits to chiropractors in the U.S. The estimate was constructed over the same time period as the literature search (1966 through the first quarter of 1998). The three sources included (a) the 1990 Seventh Report to the President and Congress on the Status of Health Personnel in the United States,²⁹ (b) the Summary of 1994 American

Chiropractic Association's (ACA) Annual Statistical Study,³⁰ and (c) the 1994 Job Analysis of Chiropractic by State conducted by the National Board of Chiropractic Examiners.³¹ Although a 1995 ACA statistical survey³² has been published, it was not utilized as the methodology departed considerably from previous years by including non-members as well, which eliminated the ability to compare the data with previous years. Thus, while the approach to encompass non-members will ultimately yield a clearer statistical profile of chiropractic practice variables, the 1995 ACA survey lacked the specificity regarding important distinctions such as number of licensed chiropractors versus active chiropractors, differentiation of patient profiles by age (pediatric, as in previous ACA surveys limited this group to age 16 rather than through age 17) and average number of visits per week. Thus, the three sources described, collectively represented the best composite of information sufficient to meet the information requirements for this study.

Additionally, while information relative to chiropractic practice characteristics in other countries has been mentioned, it was not utilized in the calculation of N/VB risk to pediatric patients under chiropractic care in the U.S. Also, for comparative purposes, risk factors associated with certain medical procedures and other phenomena have also been considered (Table 1). While the present study is directed toward the pediatric patient, some relevant information dealing with the adult population under chiropractic care has been presented as well. The intention for providing this information has been to elaborate distinctions that must be made in evaluating the literature for reports of various types of complications attributed to chiropractic care.

Categorization

From the sources utilized, seven categories were developed to estimate the number of pediatric visits per annum (Table 2). These included: (1) The year in which the study was conducted (generally in survey format), (2) Interval between studies, (3) Number of chiropractors estimated to be in active practice, (4) Number of practicing weeks per year, (5) Total number of visits per year, (6) Percentage of visits reflecting pediatric patients (usually 17 years or younger), and (7) Number of visits at each study interval(s). During periods for which there was no reported data sufficient to derive information relative to the seven categories above, data from the previous year's report were substituted.

Categories (1) and (2) were a composite of data available from the three sources. Category (3) was derived from information in the 1990 Seventh Report to the President and Congress. In regard to category (4), the working values were derived by averaging the years 1984 - 1994 from the ACA Summaries, and the 1990 Seventh Report to the President and Congress. Category (5) was derived by averaging data from the 1990 Seventh Report to the President and Congress³³, and the ACA annual statistical evaluation for the years 1984-1994. Category (6) was determined by averaging ACA survey estimates for the years 1984,³⁴ 1986,³⁵ 1988,³⁶ 1990,³⁷ 1991,³⁸ 1992,³⁹ 1993,⁴⁰ and 1994⁴¹; values from the Seventh Report to the President and Congress (1990), and values from the 1994 report from the National Board of Chiropractic Examiners.⁴²

Table 1. Risk Estimates of Twelve Types of Complications for Comparison to the Risk of Neurological and/or Vertebrobasilar Incidents in Chiropractic Pediatric Patients.

<i>Risk (%)</i>	<i>Event</i>	<i>Type of Estimate</i>	<i>Source</i>
30	Incidence of adverse drug event in hospitalized patients in the U.S.	Estimated for the U.S. population.	Anderson, 1992 ¹¹⁵
10	Incidence of psychosis due to corticosteroid therapy.	Estimated for all individuals taking steroids.	Havey, 1984 ¹¹⁶
7-10	Incidence of hepatitis due to blood transfusion.	Estimated for the U.S. population.	Stehling, 1986 ¹¹⁷
3.76	Incidence of nosocomial infection in hospitalized patients in the U.S.	Based on records compiled by NCHS.†	C.D.C., 1991 ¹¹⁸
0.7	Incidence of esophageal perforation during anterior approach to cervical spine surgery.	Estimate based on literature review.	van Berge Henegouwan et al., 1991 ¹¹⁹
0.3-0.9	Incidence of death due to cervical spine surgery.	Estimate based on 5 years survey data from the Spine Research Society	Graham, 1989 ¹²⁰
0.057	Incidence of seizure due to DPT Vaccine.	Estimated based on U.S. records compiled by VAERS. ±	C.D.C., 1994 ¹²¹
0.012	Incidence of breast cancer due to mammography.	Calculation based on absolute risks. ‡	Bushong, 1984 ¹²²
0.005-0.015	Incidence of death from radiation-induced malignancy due to x-ray exposure of 1-RAD.	Calculated based on absolute risks. ‡	Bushong, 1984 ¹²²
0.0025-0.01	Incidence of death due to radiocontrast media.	Estimate based on data from 10 mil. Injections given in the U.S.	Atkinson & Kaliner, 199 ¹²³
0.001-0.0008	Incidence of death due to allergic reaction to anesthetic agents.	Estimate for patients undergoing anesthesia.	Anderson, 1992 ¹²⁴
0.00002-0.00008	Incidence of serious neurologic/ vertebrobasilar complications due to spinal manipulations (adults).	Estimated risks.	Gutmann ¹²⁵ Cyriax ¹²⁶

† NCHS is the National Center for Health Care Statistics of the C.D.C.

± VAERS is the Vaccine Adverse Event Reporting System of the C.D.C.

‡ (Number of incidents /106 persons/rad/ yrs) * (Number of procedures performed/rad/yrs)

Table 2. Estimated Number of Chiropractic Visits made by Pediatric Patients in the United States from 1966 to 1998. †

Year of Estimate ^{a-c}	Interval (Yrs) ^{a-c}	No. of Active Chiropractors	Category			
			Practice Activity ^{a,b} (Wks)	Visits (Wk) ^{a,b}	Pediatric Patients ^{a-c} (%)	Total Visits
1978	1.0	23,400	50.4	127.0	9.0	13,480,085
1979	1.0	23,400	50.4	127.0	9.0	13,480,085
1980	4.0	25,600	50.4	127.0	9.0	58,989,772
1984	4.0	31,500	50.4	120.1	9.0	68,641,474
1988	2.0	39,000	50.4	120.1	9.0	42,492,341
1990	4.0	41,500	50.4	125.7	9.0	94,649,083
1994	1.0	41,500	50.4	125.7	9.0	23,662,271
1995-1998	3.3	41,500	50.4	127.0	9.0	78,893,064
Retrospective Estimate						
1966-1977	12.0	15,608	50.4	127.0	9.0	107,895,981
Sum Total						502,184,156

a. Data derived in part from Seventh Report to the President and Congress.¹¹²

b. Data derived in part from Summary of 1994 ACA Annual Statistical Study.¹¹³

c. Data derived in part from Job Analysis of Chiropractic by State.¹¹⁴

† See Methods for estimation calculations.

Calculations

The following formula was used to derive each periodic estimate of pediatric visits:

$$\text{Category (2) } \times \text{ (3) } \times \text{ (4) } \times \text{ (5) } \times \text{ (6) } = \text{ (7)}$$

The total number of periodic estimates was then summed (Table 2). In order to construct the most meaningful estimate of pediatric chiropractic visits, it was necessary to construct an estimate which covered approximately the same time span over which the literature search was conducted; i.e., between the years 1966–first quarter of 1998. In that regard, essentially no survey data, representative of the chiropractic profession as a whole, was available between 1966 - 1977 (approximately one decade). Thus, data for this period was, for the most part, carried over from data derived from the three sources covering the period of 1978 through the first quarter of 1998. However, it was deemed appropriate to reduce category 3 (No. of active chiropractors) by 66.7%, as this change closely approximated the average increase in this category for the decade between 1978 and 1988 (Table 2).

Literature Search

A Medline search of the literature from years 1966–the first quarter of 1998, using the Medical Subject Heading (MeSH) keywords: *chiropractic, adjustment, manipulation, complication and child /children* was performed to find any reports of adverse events following chiropractic care in the pediatric population. Additionally, the database of Mantis was searched using the same

subject headings from 1970, representing the origin date of the database, through the first quarter of 1998 (32.25 yrs). References provided by the articles found were also searched by citation index for other studies reporting pertinent information regarding risk assessment relative to the pediatric population. Reports of injury to children as a result of treatments not performed by chiropractors were not considered.

Results

The literature search between 1966 and the first quarter of 1998 included only two reports of N/VB complications. These were found in the Medline and Mantis databases of scientific and clinical literature, one in 1978 and the other in 1992.

In the first of the two reports (1978) Zimmerman et al.,⁴³ reported a case of a seven year old boy suffering from headaches and transient cranial nerve deficits after vigorous gymnastics and repeated manipulations of the cervical spine by a chiropractor. The author goes on to hypothesize that passive stretching of the cervical spine during chiropractic maneuvers may have lead to vertebral artery thrombosis. However this theory is speculative, lacking any evidence to support the claim. Additionally, it cannot be determined what role, if any, “vigorous gymnastics” played in the child’s condition. It is noteworthy, however, that trauma induced by athletic injuries has been reported to cause occlusive vertebral arterial flow.⁴⁴

In the second of the two studies involving pediatric patients, Shafirir and Kaufman (1992)⁴⁵ discussed the case of a child with a spinal cord tumor (astrocytoma) who presented to a chiropractor complaining of torticollis (Wry Neck). However, reports

of torticollis associated with astrocytoma tumor are rare.^{46,47} Following chiropractic care, the child became quadriplegic, allegedly as a result of cervical manipulation. While astrocytoma has been reported to be a congenital condition in numerous medical publications,⁴⁸⁻⁵⁸ there exists no evidence to support the claim of a complication arising as a result of chiropractic care. Once again, this report is speculative at best lacking any scientific evidence to support the claim.

Risk Assessment

Table 1 depicts risk assessments from the scientific/clinical literature reporting a range of topics common to the western medical model. Risk assessment for N/VB complications in the pediatric chiropractic population was derived by dividing the total reported cases by the total number of visits that could be conservatively constructed over the same time period during which the literature was searched. In that time period a total of 502,184,156 visits were estimated (Table 2). In the scientific/clinical literature, two reports of pediatric neurological complications were reported to be associated with chiropractic "manipulations." Thus, the risk associated with chiropractic care, is at best estimate (number of reported complications/total number of visits), calculated to be 4.0×10^{-7} % per visit. Stated otherwise, there would be a chance of about 1 in 250 million pediatric visits that a N/VB complication would result.

Discussion

Based on studies of associated risks in the adult population under chiropractic care by Dabbs & Lauretti,⁵⁹ Dvorak,⁶⁰ Gutmann,⁶¹ Cyriax⁶² and others,^{63,64} the incidence of stroke from cervical manipulation has been estimated to be in the range of 1-3 per million cervical manipulations and/or adjustments. Terrett has determined from the literature spanning 1934 - 1998, that only fifty reports of vertebral stroke can be attributed to chiropractors.⁶⁵ Considering all reports of vertebral complications from Terrett, as well as reports by Shafir and Kaufman, and Zimmerman et al., there are a total of 52 reports of neurological and/or vertebral complication, of which two are related to the pediatric patient.

In regard to the adult patient population, Terrett's review of the literature found that among 78 cases of vertebral stroke following putative "chiropractic" manipulation, that 35.89% were not performed by chiropractors. These other "spinal manipulators" included a kung-fu practitioner⁶⁶, an Indian barber⁶⁷, a blind masseur,⁶⁸ assorted medical doctors,⁶⁹⁻⁸⁴ nurses,^{85,86} osteopaths,⁸⁷⁻⁹⁶ various physiotherapists,⁹⁷⁻¹⁰⁰ wives,^{101,102} and people doing self-manipulation.¹⁰³⁻¹⁰⁷ It is unfortunate that such inaccurate reporting occurs as it misleads the scientific community, and the general public, as to the risks associated with chiropractic care.

The low number of published reports concerning N/VB complications in regard to the pediatric population requires comment. As mentioned, the search covering 32.25 years of scientific/clinical literature resulted in only two reported cases of childhood injury attributed to chiropractic care. There are several possible reasons for this. First, research contributions to the

scientific/clinical literature concerning pediatric chiropractic care are in the fledgling stage, as the profession has only recently celebrated its first centennial.¹⁰⁸ Secondly, perhaps the incidences of complications in the areas addressed in this study are indeed rare. Third, perhaps reports have been published in journals, or periodicals, not indexed. If this were the case, it would be possible to overlook such reports. Moreover, it may be that such complications occur, but are not reported in any form of publication, but may be archived in hospital, or other records.

Because this possibility exists, a thorough search of non-disseminated, but public, records will eventually have to be conducted, preferably on a continuous basis. For example, where possible, medical records of pediatric patients sustaining N/VB complications should be studied to ascertain if any link could be established to prior chiropractic care. Studies of this type should be conducted on a periodic basis. Moreover, the necessity to ascertain the number of visits, adjustments, and/or manipulations must also be documented to calculate risk factors. As revealed in the present study, it was necessary to be eclectic in deriving the information necessary to estimate the number of pediatric visits. Because different surveys have unique objectives, it is apparent that the results are not directly comparable. This study makes it apparent that some concentrated effort must be exercised to gather the data required for risk assessment in one survey format, either by one organization, or shared by several following the same methods.

This level of professional inquiry is not only the responsibility of the chiropractic discipline which views itself as extremely safe, but it is essential in terms of advising patients, or guardians, of the potential for harm (even if it is remarkably small). It is encouraging to recognize that so few reports of complications (concerning adults or pediatric patients) associated with chiropractic care exist in the scientific/clinical literature. However, as described above, that level of reporting alone cannot be taken as the only index of verifying the safety of chiropractic care for the pediatric patient. Alternative to this viewpoint is the logical assumption that if indeed N/VB complications represented a frequent pattern, reports of such incidents would be expected to be found in the widely disseminated literature.

Regardless of the reasons which account for the few reports of N/VB complications in the pediatric population under chiropractic care, epidemiological studies will be required to document practice statistics concerning the number of pediatric visits, adjustments, and complications. To date, these have yet to be performed by those in the chiropractic profession, or by others studying the chiropractic profession in particular. Nevertheless, given the limitations of the literature pertaining to chiropractic care, specifically in regard to pediatric patients, the objective of the present study was to provide an initial estimate of risk of the occurrence of N/VB complications based upon what data is available. This has been done in full recognition that this first published estimate will require further studies by the research community to document its accuracy.

In this regard, it is suggested that organizations interested in reporting the most accurate estimates of risk begin the process by developing questionnaires that provide the necessary information relative to accurately arrive at such estimates. To date, this has not been the case. Most reports have lacked methodological

sophistication, including government surveys and those conducted by chiropractic organizations.

Although other risk factors were presented in the present study for comparative purposes (Table 1), caution must be exercised in either criticizing the higher risks associated with other disciplines, or boasting the safety of chiropractic pediatric care. In fact, it will be necessary through future data gathering efforts to demonstrate more conclusively that the concept of safety espoused by chiropractic is not an illusion created by the lack of proper reporting of incidents, if and when they do occur.

Equally important to risk is the concept of risk/benefit ratio. As previously mentioned, when considering the use of any health care procedure, the expected benefit must be weighed against the inherent risks as well as the consequences of foregoing said procedure. Based on this axiom, chiropractic care relative to neurological and/or vertebrobasilar complications appears to present little risk to the pediatric patient when compared to cited reports related to benefits of chiropractic care. While some pre-existing conditions such as Down's syndrome, cardiac diseases, arteritis, meningitis, clotting abnormalities, various arthritic conditions as well as symptoms of vertebrobasilar insufficiency¹⁰⁹⁻¹¹¹ may predispose the pediatric patient to a higher probability of neurological and/or vertebrobasilar complication, the estimate provided is considered applicable to the general pediatric population. It will be necessary, and of interest, to re-evaluate this estimate as more data is acquired within larger groups of patients, measured under conditions of appropriate methodology applicable to survey research.

Summary and Conclusions

1. Based on the prevalent scientific/clinical literature spanning the last 32.25 years, there are only two reported cases related to pediatric complications and chiropractic care, which fit into the category of N/VB complications.
2. Based on an eclectic summation of data derived from three sources, a conservative estimate of the number of pediatric visits to chiropractors in the U.S. over the same time span amount to 502,184,156.
3. This information provides an estimate of the risk of a N/VB complication occurring in one out of approximately every 250,000,000 visits, or 4.0×10^{-7} %.
4. There is a need for serious efforts from the chiropractic profession, and related disciplines to solicit ongoing information generating sufficient data to derive more definitive estimates of risk, especially in regard to the pediatric chiropractic population.

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References

1. Spiegelblatt L, Lainé-Ammara G, Pless IB, Guyver A. The use of alternative medicine by children. *Pediatrics* 1994; 94(6 Pt 1):811-4.
2. Kent C. Research on purpose. *The Chiropractic Journal* 1997; 11(9):23,30.
3. Schmitt HP. Anatomical structure of the cervical spine with reference to pathology of manipulation complication. *J Manual Medicine* 1991; 6:93-101.
4. Khurana DS, Bonnemann CG, Dooling EC, Ouellette EM, Buonanno F. Vertebral artery dissection: issues in diagnosis and management. *Pediatr Neurol* 1996; 14(3):255-8.
5. Alvarez-Sabín J. Stroke in teenagers. *Rev Neurol* 1997;25(142):919-23.
6. Ruge JR, Sinson GP, McLone DG, Cerullo LJ. Pediatric spinal injury: the very young. *J Neurosurg* 1988;68:25-30.
7. Greenman PE. Principles of manipulation of the cervical spine. *J Manual Medicine* 1991; 6: 106-13.
8. Ruge JR, Sinson GP, McLone DG, Cerullo LJ. Pediatric spinal injury: the very young. *J Neurosurg*. 1988; 68:25-30.
9. Author's notes, Life University Fellowship in Chiropractic Pediatrics, Module 1, conducted, by Larry L. Webster, D.C. Atlanta, GA. Jan 13-14, 1996.
10. Schmitt HP. Ruptures and thromboses of the vertebral artery following closed mechanical injuries. *Schweiz Arch Neurol Neurochir Psychiatr* 1976; 119(2):363-9.
11. Crawford JP, Byoung YH, Asselbergs PJ, Hickson GS. Vascular ischemia of the cervical spine: A review of the relationship to therapeutic manipulation. *J Manipulative Physiol Ther* 1984; 7(3):149-55.
12. Dvorak J, Baumgartner L, Burn JB, et al. Consensus and recommendations as to the side effects and complications of manual therapy of the cervical spine. *J Manual Medicine* 1991; 6:117-8.
13. Fossgren J. Complications in manual medicine. *J Manual Medicine* 1991;6:83-4.
14. Eisenberg DM, Kessler RC, Foster C, Norlock FE, Calkins DR, Delbanco TL. Unconventional medicine in the United States. Prevalence, costs and patterns of use. *N Engl J Med* 1993; 328(4):246-52.
15. Spiegelblatt L, Lainé-Ammara G, Pless IB, Guyver A. The use of alternative medicine by children. *Pediatrics* 1994; 94(6 Pt 1):811-4.
16. Office des Professions du Québec-direction de la recherche. Sondage effectué en vue de l'application des lois professionnelles sur l'opportunité de constituer une corporation professionnelle dans le domaine des médecines douces-publicatio du Gouvernement du Québec, Aout 1991.
17. Profile of census division and subdivision in Quebec, Part A. Ottawa: Supply and Services Canada, 1992. 1991 Census of Canada. Catalogue No. 95-332.
18. Vange B. Contact between preschool children with chronic diseases and the authorized health services and forms of alternative therapy. *Ugeskr Laeger* 1989;151(28):1815-8 1989.
19. Masarsky C; Weber M; Chiropractic and lung volumes - A retrospective study. *ACA J of Chiropr* 1986; 23(9): 65-8.
20. Kessinger R; Changes in pulmonary function associated with upper cervical specific chiropractic care. *J Vertebral Subluxation Res* 1997; 1(3): 43-9
21. Hviid C; A comparison of the effect of chiropractic treatment on respiratory function in patient's with respiratory distress symptoms and patients without. *Bull Eur Chiro Union* 1978; 26: 17-34.
22. Leboeuf C; Brown P; Herman A; Leembruggen K; Walton D; Crisp TC; Chiropractic care of children with nocturnal enuresis: a prospective outcome study. *J Manipulative Physiol Ther* 1991; 14(2): 110-5.
23. Gemmill HA; Jacobson BH; Chiropractic management of enuresis: time-series descriptive design. *J Manipulative Physiol Ther* 1989; 12(5): 386-9.
24. Blomert PR; Functional nocturnal enuresis. *J Manipulative Physiol Ther* 1994; 17(5): 335-8.
25. Froehle RM; Ear infection: a retrospective study examining improvement from chiropractic care and analyzing for influencing factors. *J Manipulative Physiol Ther* 1996; 19(3): 169-77.
26. Giesen JM; Center DB; Leach RA; An evaluation of chiropractic manipulation as a treatment of hyperactivity in children. *J Manipulative Physiol Ther* 1989; 12(5): 353-63.
27. Klougart N, Nilsson N, Jacobsen J. Infantile colic treated by chiropractors: a prospective study of 316 cases. *J Manipulative Physiol Ther* 1989; 12(4): 281-8.

28. Wolf FM. Meta-analysis: Quantitative Methods for Research Synthesis. Beverly Hills. Sage Publications, 1986.
29. U.S. Department of Health and Human Services. Seventh Report to the President and Congress on the Status of Health Personnel in the United States.; Rockville, Md., 1990. US Dept of Health and Human Services; Health Resources and Services Administration. Bureau of Health Professions: DHHS publication HRS-P-OD-90-1.
30. Plamondon RL. Summary of 1994 ACA Annual Statistical Survey. JACA 1995; 32(1):57-63.
31. Christensen M, et al. Job analysis of chiropractic by state. 1st ed. Greeley; National Board of Chiropractic Examiners 1994.
32. Goertz C. Summary of 1995 ACA Annual Statistical Survey. JACA 1996; 33(6):35-41.
33. U.S. Department of Health and Human Services. Seventh Report to the President and Congress on the Status of Health Personnel in the United States.; Rockville, Md., 1990. US Dept of Health and Human Services; Health Resources and Services Administration. Bureau of Health Professions: DHHS publication HRS-P-OD-90-1.
34. ACA Department of Research and Statistics. 1984 Annual Survey and Statistical Study. JACA 1985; 22(2):56.
35. ACA Department of Research and Statistics. 1986 Annual Survey and Statistical Study. JACA 1987; 24(2): 68-9.
36. Brennan MJ. 1988 Annual Survey and Statistical Study. JACA 1989; 26(1):52-4.
37. Department of Informational Resources. 1990 Annual Survey and Statistical Study. JACA 1991; 28(2): 52-60.
38. Plamondon RL. Summary of 1991 ACA Annual Statistical Survey. JACA 1992; 29(2):59-65.
39. Plamondon RL. Summary of 1992 ACA Annual Statistical Survey. JACA 1993; 30(2):36-42.
40. Plamondon RL. Summary of 1993 ACA Annual Statistical Survey. JACA 1994; 31(2):40-6.
41. Plamondon RL. Summary of 1994 ACA Annual Statistical Survey. JACA 1995; 32(1):57-63.
42. Christensen M, et al. Job analysis of chiropractic by state. 1st ed. Greeley; National Board of Chiropractic Examiners 1994.
43. Zimmerman AW, Kumar AJ, Gadoth N, Hodges FJ 3d. Traumatic vertebral basilar occlusive disease in childhood. Neurology 1978; 28(2):185-8.
44. Nagler W. Vertebral artery obstruction by hyperextension of the neck: report of three cases. Arch Phys Med Rehabil 1973; 54(5): 237-40.
45. Shafir Y, Kaufman BA. Quadriplegia after chiropractic manipulation in an infant with congenital torticollis caused by a spinal cord astrocytoma. J Pediatr 1992; 120 (2 Pt 1):266-9.
46. Kiwak KJ, Deray MJ, Shields WD. Torticollis in three children with syringomyelia and spinal cord tumor. Neurology 1983;33(7):946-8 1983.
47. Bussieres A, Cassidy JD, Dzus A. Spinal cord astrocytoma presenting as torticollis and scoliosis. J Manipulative Physiol Ther 1994; 17(2):113-8.
48. Cooperman E, Marshall KG, Haust MD. Congenital astrocytoma. Can Med Assoc J 1967; 97(23):1405-7.
49. Subaramanian MV, Raja Reddy D, Prabhakar V, Dayananda Rao B. Congenital astrocytoma. Indian Pediatr 1971; 8(6):200-2.
50. Masson A, Heldt N, Cronmuller G, Schneegans E. Congenital astrocytoma of the brain stem. Ann Pediatr (Paris) 1971; 18(12):789-95.
51. Lin SR, Lee KF, O'Hara AE. Congenital astrocytomas: the roentgenographic manifestations. Am J Roentgenol Radium Ther Nucl Med 1972; 115(1):78-85 1972.
52. Rothman SM, Nelson JS, DeVivo DC, Coxe WS. Congenital astrocytoma presenting with intracerebral hematoma. Case report. J Neurosurg 1979; 51(2):237-9.
53. DeSousa AL, Kalsbeck JE, Mealey J Jr, Campbell RL, Hockey A. Intraspinal tumors in children. A review of 81 cases. J Neurosurg 1979; 51(4):437-45.
54. Reimer R, Onofrio BM. Astrocytomas of the spinal cord in children and adolescents. J Neurosurg 1985;63(5):669-75.
55. Citron N, Edgar MA, Sheehy J, Thomas DG. Intramedullary spinal cord tumors presenting as scoliosis. J Bone Joint Surg [Br] 1984;66(4):513-7.
56. Umemoto M, Azuma E, Ohshima S, Arai S, Itoh M, Matsuda T. Congenital astrocytoma in the cervical spinal cord. Am J Dis Child 1990; 144(7):744-6.
57. Epstein F. Spinal cord astrocytomas of childhood. Adv Tech Stand Neurosurg 1986;13:135-69 1986.
58. Kaufman BA, Park TS. Congenital spinal cord astrocytomas. Childs Nerv Syst 1992; 8(7):389-93 1992.
59. Dabbs V, Lauretti WJ. A risk assessment of cervical manipulation vs. NSAIDs for the treatment of neck pain. J Manipulative Physiol Ther 1995; 18(8):530-6.
60. Dvorak J, Orelli F. How dangerous is manipulation to the cervical spine. Manuelle Medizin 1985; 2:1-4.
61. Gutmann G. Injuries to the vertebral artery caused by manual therapy. Manuelle Medizin 1983; 21:2-14.
62. Cyriax J, Russell G. Textbook of orthopaedic medicine, volume 2. Treatment by manipulation, massage, and injection. 9th Ed Williams and Wilkins.
63. Jaskoviak P. Complications arising from manipulation of the cervical spine. J Manipulative Physiol Ther 1980; 3:213.
64. Klougart N, Leboeuf-Yde C, Rasmussen LR. Safety in chiropractic practice, Part I; The occurrence of cerebrovascular accidents after manipulation to the neck in Denmark from 1978-1988. J Manipulative Physiol Ther 1996;19(6):371-7.
65. Terrett AGJ. Vertebral basilar stroke following manipulation. NCMIC publication. Des Moines 1996.
66. Chen TW, Chen ST. Brainstem stroke induced by chiropractic neck manipulation—a case report. Chung Hua I Hsueh Tsa Chih 1987;40(6):557-62.
67. Murthy JM, Naidu KV. Aneurysm of the cervical internal carotid artery following chiropractic manipulation. J Neurol Neurosurg Psychiatry 1988;51(9):1237-8.
68. Putman TD, Wu Y. Tracheal rupture following cervical manipulation: late complication posttracheostomy. Arch Phys Med Rehab 1986; 67:48-50.
69. Hardin CA, Williamson P, Steegman A. Vertebral artery insufficiency produced by cervical osteoarthritic spurs. Neurology 1960; 10: 855-8.
70. Roche L, Collin M, DeRougemont J, Vedrin J, Vitni C, Tomasi M. Lesions traumatiques de la colonne cervicale et atteintes de l'artere vertebrale. Responsibilite d'une examen medicale. Ann Med Leg 1963; 43:232-5.
71. Kramer KH. Wallenberg Syndrom Nach manueller Behandlung. Manuelle Medizin 1974; 12:88-9.
72. Kosoy J, Glassman AL. Audiovestibular findings with cervical spine trauma. Tex Med 1974; 70(10):66-71.
73. Hensell V. Neurologic lesions following chiropractic measurements of the spine. Med Welt 1976; 24(14): 656-8.
74. Schmitt HP. Ruptures and thromboses of the vertebral artery following closed mechanical injuries. Schweiz Arch Neurol Neurochir Psychiatr 1976; 119(2):363-9.
75. Gorman RF. Cardiac arrest after cervical manipulation. Ann Neurol 1977; 1(3):308.
76. Nyberg-Hansen R, Loken AC, Tenstad O. Brainstem lesion with coma for five years following manipulation of the cervical spine. J Neurol 1978; 218:97-105.
77. Meyermann R. Moglichkeiten einer schädigung der arteria vertebralis. Manuelle Medizin 1982; 20:105-14.
78. Gutmann G. Injuries to the vertebral artery caused by manual therapy. Manuelle Medizin 1983; 21:2-14.
79. Bayerl JR, Buchmüller HR, Pohlmann-Eden B. Side effects and contraindications of manual therapy in the area of the cervical spine. Nervenarzt 1985; 56(4):194-9.
80. Terrett AGJ. Vascular Accidents from Cervical Spine Manipulation: Report on 107 Cases. J Aust Chiropr Assoc 1987;17(1):15-24.
81. Frisoni GB, Anzola GP. Vertebral basilar ischemia after neck motion. Stroke 1991; 22(11):1452-60.
82. Braune HJ, Munk MH, Huffmann G. Cerebral infarct in the circulatory area of the arteria cerebri media following chiropractic therapy of the cervical spine. Dtsch Med Wochenschr 1991; 116(27):1047-50.
83. Schmitt HP. Manual therapy in the region of the cervical spine. Manual therapy of the cervical spine and its dangers: ruptures and occlusions of the vertebral artery. ZFA (Stuttgart) 1978; 54(8):467-74.
84. Hamann G, Felber S, Haass A, Strittmatter M, Kujat C, Schmirgik K, Piepgras U. Cervicocephalic artery dissections due to chiropractic manipulations. Lancet 1993; 341:764-5
85. Gutmann G. Injuries to the vertebral artery caused by manual therapy. Manuelle Medizin 1983; 21:2-14.
86. Schmitt HP, Tamaska L. Dissecting rupture of vertebral artery with fatal

- thrombosis of vertebral and basilar arteries. *Z Rechtsmedizin* 1973; 73(4):301-8.
87. Smith RA, Estridge MN. Neurologic complications of head and neck manipulations. *JAMA* 1962; 182 (5): 528-31.
 88. Lyness SS, Wagman AD. Neurological deficit following cervical manipulation. *Surg Neurol* 1974; 2(2):121-4.
 89. Goodbody RA. Fatal post-traumatic vertebrobasilar ischemia. *J Clin Pathol* 1976; 29(1): 86-7.
 90. Daneshmend TK, Hewer RL, Bradshaw JR. Acute brain stem stroke during neck manipulation. *Br Med J (Clin Res Ed)* 1984; 288(6412):189 .
 91. Fritz VU, Maloon A, Tuch P. Neck manipulation causing stroke. Case reports. *S Afr Med J* 1984; 66(22):844-6.
 92. Lindy DR. Patient collapse following cervical manipulation: A case report. *Br Osteopathic J* 1984; 16(2):84-5.
 93. Brownson RJ, Zollinger WK, Madeira T, Fell D. Sudden sensorineural hearing loss following manipulation of the cervical spine. *Laryngoscope* 1986; 96(2):166-70.
 94. Bolton SP. Vascular accidents. *J Aust Chiropr Assoc* 1987; 17(2):75.
 95. Terrett AGJ. Osteopath iatrogenics and the need for government regulation. *J New Zealand Register of Osteopaths* 1990; 4: 42-5.
 96. Povlsen UJ, Kjaer L, Arlien-Soborg P. Locked-in syndrome following cervical manipulation. *Acta Neurol Scand* 1987; 76(6):486-8.
 97. Masson M, Cambier J. Insuffisance circulatoire vertebro basilaire. *Press Medicale* 1962; 70(43):1990-3.
 98. Parkin PJ, Wallis WE, Wilson JL. Vertebral artery occlusion following manipulation of the neck. *NZ Med J* 1978; 88:441-3.
 99. Nielsen AA. Cerebrovascular insults caused by manipulation of the cervical spine. *Ugeskr Laeger* 1984; 146(43):3267-70 .
 100. Dunne DW, Conacher GN, Khangure M, Harper CG. Dissecting aneurysms of the vertebral arteries following cervical manipulation: a case report. *J Neurol Neurosurg Psychiatry* 1987; 50(3): 349-53.
 101. Ford FR, Clark D. Thrombosis of the basilar artery with softenings in the brain stem due to manipulation of the neck. *Bull John Hopkins Hosp* 1956; 98:37-42.
 102. Lyness SS, Wagman AD. Neurological deficit following cervical manipulation. *Surg Neurol* 1974; 2(2):121-4.
 103. Schellas KP, Latchaw RE, Wendling LR, Gold LHA. Vertebrobasilar injuries following cervical manipulation. *JAMA* 1980; 244(13): 1450-3.
 104. Rothrock JF, Hesselink JR, Teacher TM. Vertebral artery occlusion and stroke from cervical self-manipulation. *Neurology* 1991; 41(10):1696-7 .
 105. Cook JW 4th, Sanstead JK. Wallenberg's syndrome following self-induced manipulation. *Neurology* 1991; 41(10):1695-6 .
 106. Johnson DW, Whiting G, Pender MP. Cervical self-manipulation and stroke. *Med J Aust* 1993; 158(4):290.
 107. Murase S, Ohe N, Nokura H, Miwa Y, Ohkuma A. Vertebral artery injury following mild neck trauma: report of two case. *No Shinkei Geka* 1994; 22(7):671-6.
 108. Palmer D.D. *The Chiropractor* 1914 Kila, MT: Kessinger Publishing Company 1997.
 109. Greenman PE. Principles of manipulation of the cervical spine. *J Manual Medicine* 1991; 6: 106-13.
 110. Crawford JP, Byoung YH, Asselbergs PJ, Hickson GS. Vascular ischemia of the cervical spine: A review of the relationship to therapeutic manipulation. *J Manipulative Physiol Ther* 1984; 7(3):149-55.
 111. Latchaw RE, Seeger JF, Gabrielsen TO. Vertebrobasilar arterial occlusions in children. *Neuroradiol* 1974; 8: 141-7.
 112. U.S. Department of Health and Human Services. Seventh Report to the President and Congress on the Status of Health Personnel in the United States.; Rockville, Md., 1990. US Dept of Health and Human Services; Health Resources and Services Administration. Bureau of Health Professions: DHHS publication HRS-P-OD-90-1.
 113. Plamondon RL. Summary of 1994 ACA Annual Statistical Survey. *JACA* 1995; 32(1):57-63.
 114. Christensen M, et al. Job analysis of chiropractic by state. 1st ed. Greeley; National Board of Chiropractic Examiners 1994.
 115. Anderson JA. Allergic reactions to drugs and biological agents. *JAMA* 1992; 268(20):2845-57.
 116. Havey RJ. Over-the-counter and iatrogenically induced psychoses: a review of the literature. *J Am Osteopath Assoc* 1984; 83(6):412-8.
 117. Stehling LC. Anesthesiology update #19. Adverse reactions to transfusion. *Orthop Rev* 1986; 15(11):736-40.
 118. CDC. MMWR 1991; 40(39): 675-8. Centers for Disease Control and Prevention, 1600 Clifton Rd., NE, Atlanta, GA 30333, USA.
 119. van Berge Henegouwen DP, Roukema JA, de Nie JC, v.d. Werken C. *Neurosurgery* 1991; 29(5):766-8.
 120. Graham JJ. Complications of cervical spine surgery. A five-year report on a survey of the membership of the Cervical Spine Research Society by the Morbidity and Mortality Committee. *Spine* 1989; 14(10):1046-50.
 121. CDC. General Recommendations on Immunization, Recommendations of the Advisory Committee on Immunization Practices (ACIP) MMWR 1994; 43(RR-1) Centers for Disease Control and Prevention, 1600 Clifton Rd., NE, Atlanta, GA 30333, USA.
 122. Bushong SC. Radiologic science for the technologist: Physics, biology and protection. 3rd ed. St. Louis, MO. C.V. Mosby Publishing Co. 1984.
 123. Atkinson TP, Kaliner MA. Anaphylaxis. *Med Clin North Am* 1992; 76(4):841-55.
 124. Anderson JA. Allergic reactions to drugs and biological agents. *JAMA* 1992; 268(20):2845-57.
 125. Gutmann G. Injuries to the vertebral artery caused by manual therapy. *Manuelle Medizin* 1983; 21:2-14.
 126. Cyriax J, Russell G. Textbook of orthopaedic medicine, volume 2. Treatment by manipulation, massage, and injection. 9th Ed Williams and Wilkins.