The shifting burden of neurosurgical disease: Vietnam and the middle-income nations

Christopher Carr, MD, MPH,¹ Lora Kahn, MD,¹ Mansour Mathkour, MD, MSc, MSCR,¹ Erin Biro, MD,² Cuong J. Bui, MD,² and Aaron S. Dumont, MD, MBA³

¹Tulane University-Ochsner Clinic Foundation Program, Department of Neurosurgery, Tulane University Medical Center;

²Department of Neurosurgery, Ochsner Health System; and ³Department of Neurosurgery, Tulane University Medical Center, New Orleans, Louisiana

OBJECTIVE The Global Burden of Disease (GBD) is an international collaboration and the largest comprehensive investigation of global health disease burden ever conducted. It has been particularly insightful for understanding disease demographics in middle-income nations undergoing rapid development, such as Vietnam, where 6 of the top 10 causes of death are relevant to the neurosurgeon. The burden of stroke—the number one cause of death in Vietnam—is particularly impressive. Likewise, road injuries, with a disproportionate rate of traumatic brain injury, continue to increase in Vietnam following economic development. Low-back and neck pain is the number one cause of disability. Simultaneously, more patients have access to care, and healthcare spending is increased.

METHODS It is imperative that neurosurgical capital and infrastructure keep pace with Vietnam's growth. The authors searched the existing literature for assessments of neurosurgical infrastructure or initiatives to address neurosurgical disease burden. Using GBD data, the authors also abstracted data for death by cause and prevalence of years of life lost due to disability (YLD) for common neurosurgical pathologies for Vietnam and comparison nations.

RESULTS Interventions aimed at primary prevention of risk factors for neurosurgical disease and focused on the transference of self-sustainable technical skills were found to be analogous to those that have been successful in other regions. Efforts toward stroke prevention have been focused on causal risk factors. Multiple investigators have found that interventions aimed at increasing helmet use were successful in preventing traumatic brain injury. Government-led reforms and equipment donation programs have improved technical capacity. Nevertheless, Vietnam lags behind other nations in neurosurgeons per capita; cause-attributable death and YLD attributable to neurosurgical disease are considerably higher in Vietnam and middle-income nations compared to both lower-income nations and upper-income nations.

CONCLUSIONS More than two-thirds of deaths attributable to neurosurgical pathologies in Vietnam and other middle-income nations were due to stroke, and one-fifth of both cause-attributable death and YLD was associated with neurosurgical pathologies. Vietnam and other middle-income nations continue to assume a global burden of disease profile that ever more closely resembles that of developed nations, with particular cerebrovascular, neurotrauma, and spinal disease burdens, leading to exponentially increased demand for neurosurgeons that threatens to outpace the training of neurosurgeons.

<https://thejns.org/doi/abs/10.3171/2018.7.FOCUS18297>

KEYWORDS Vietnam; neurosurgery; Global Burden of Disease; stroke; traumatic brain injury; back pain

THE Global Burden of Disease (GBD) is an international collaboration based at the University of Washington and funded through the Bill and Melinda Gates Foundation. It is the largest comprehensive investigation of global health disease burden ever conducted. The study began with the World Bank in 1990 and has been continued by the WHO. It currently involves more than 1800 researchers from more than 127 countries and con-

tains standardized data that are systematically collected on 195 nations. The survey has been particularly insightful for understanding disease demographics in middle-income nations undergoing rapid development, such as Vietnam.

According to the GBD, the WHO, and the US Centers for Disease Control and Prevention, together with the Vietnamese government, Vietnam has a population of more than 94 million and a per capita gross domestic product (GDP)

ABBREVIATIONS COPD = chronic obstructive pulmonary disease; DOHA = Direction of Healthcare Activities; GBD = Global Burden of Disease; GDP = gross domestic product; UI = uncertainty interval; YLD = years of life lost due to disability.

SUBMITTED June 5, 2018. **ACCEPTED** July 16, 2018.

INCLUDE WHEN CITING DOI: 10.3171/2018.7.FOCUS18297.

of about \$6000 US. Life expectancy is roughly 77 years for women and 70 years for men (<http://www.healthdata.org/vietnam>; <http://www.who.int/countries/vnm/en/>).²⁵ From 1990 to 2016, the proportion of total deaths in Vietnam due to communicable diseases decreased markedly as part of a greater trend over the past several decades throughout the developing world and particularly in middle-income nations (<http://www.healthdata.org/vietnam>).¹⁸

Accordingly, the top 8 leading causes of death in Vietnam in 2016 were “lifestyle diseases” (<https://vizhub.healthdata.org/gbd-compare/>; <http://www.healthdata.org/vietnam>; Table 1).³³ While such pathologies were once believed to be specific to the developed world, the GBD demonstrated that noncommunicable diseases are responsible for the majority of death and disability in middle-income nations. The top 10 causes of death in Vietnam were cerebrovascular disease, ischemic heart disease, Alzheimer disease (and other dementias), lung cancer, chronic obstructive pulmonary disease (COPD), diabetes, road injuries, chronic kidney disease, lower respiratory infection, and tuberculosis.

Of these 10 causes of death, 6 are of direct interest to the neurosurgeon, including ischemic heart disease, lung cancer, and tuberculosis; this interest is due to the propensity for thromboembolism, metastases, and CNS infection associated with these conditions. The burden of cerebrovascular disease—the number one cause of death in Vietnam—is particularly impressive: in 2010, stroke accounted for 11.2% of years of life lost in Vietnam, up from 6.6% in 1990. According to the 2017 Global Burden of Stroke report composed of GBD data,¹³ Vietnam has one of the highest proportional contributions to stroke-related death in the world. For instance, at 32%, Vietnam trailed only Macedonia in the proportion of stroke-related death in women. Although progress has been made at reducing the burden of stroke adjusted for age, a longer-living population has resulted in a greater overall stroke burden.¹³

Likewise, road injuries continue to increase in Vietnam as economic development results in more vehicles on the road. Along with its neighbors Thailand and Indonesia, Vietnam is among the world leaders in road injuries.²⁴ A high prevalence of motorized scooters has resulted in a disproportionate rate of traumatic brain injury following motor vehicle accidents (previously estimated at roughly 70% of all road injuries).^{19,21} As studies have shown superior outcomes with improved neurosurgical and neurocritical care, this compels additional investments in such neurosurgical capital.^{11,28,39}

Similar to the rest of the world, low-back and neck pain is the number one cause of disability in Vietnam (<http://www.healthdata.org/vietnam>); its prevalence has increased 29.4% since 2005. From 1990 to 2016, years of life lost due to disability (YLD) attributed to low-back and neck pain has increased from 9.71% of total YLDs to 12.14% (<https://vizhub.healthdata.org/gbd-compare/>). As such, the demand for spine surgeons is increasing. Thus, when death and disability metrics are combined, 3 of the top 4 pathologies in Vietnam are neurosurgical (cerebrovascular diseases, traumatic brain injuries, and spinal pathologies).

In addition to these pathologies, brain tumors and hy-

TABLE 1. Top 10 causes of death in Vietnam, with percentage change (2005–2016)

Rank	Cause	% Change	Percentage	Percentage (US)*
1	Stroke	+1.3	15.54	6.39
2	Ischemic heart disease	+23.5	13.13	19.65
3	Alzheimer disease	+41.4	6.42	8.62
4	Lung cancer	+35.1	5.95	6.91
5	COPD	+15.9	4.35	5.91
6	Diabetes	+30.1	4.17	2.58
7	Road injuries	+8.5	3.67	1.61
8	Chronic kidney disease	+19.1	3.21	2.98
9	Lower respiratory infection	−5.9	2.83	3.46
10	Tuberculosis	−34.6	2.82	0.034

The 2016 prevalence ratio between Vietnam and the US, calculated using the GBD data, was significantly greater than 1 for stroke, diabetes, road injuries, and tuberculosis.

* Relative proportion of deaths attributed to each disease in the US, for comparison.

drocephalus also carry a high burden of disease, particularly in poorer, nonurban communities, where delayed diagnosis is common due to lack of resources including quality imaging, cultural or religious barriers, and inadequate follow-up.^{4,5,26,27,40}

The literature has shown that disability-adjusted life years for all neurological disorders rose 37.6% from 1990 to 2015, corresponding to an older population.¹⁶ At the same time, from 1990 to 2016, the Healthcare Access and Quality Index in Vietnam increased from 36.6 to 60.3, meaning more patients had access to care, including care by neurosurgeons and other specialists (<http://www.healthdata.org/vietnam>).¹⁵ Healthcare spending is currently \$390 per capita (7.1% of GDP), up nearly 2300% from \$17 per capita (approximately 4% of GDP) in 1998 (<http://www.who.int/countries/vnm/en/>).⁴⁴

Methods

It is imperative that neurosurgical capital and infrastructure keep pace with Vietnam's growth. Accordingly, we searched the existing literature to determine if there have been any comprehensive assessments of neurosurgical infrastructure or public health initiatives to address neurosurgical disease burden. We were particularly interested in the specialties of cerebrovascular, neurotrauma, and spine.

We searched clinicaltrials.gov, the Cochrane Library, Embase, Google Scholar, PubMed, Web of Science, and the CINAHL (Cumulative Index to Nursing and Allied Health Literature) nursing database using the keywords “Vietnam and neurosurgery” and MeSH terms related to stroke and cerebrovascular disease, neurotrauma, and low-back and neck pain for articles pertaining to neurosurgical infrastructure changes in Vietnam or public health interventions to address stroke and cerebrovascular disease, road accidents, and low-back and neck pain. We also searched the professional economics literature using the

JSTOR, EconLit, and World Development Indicators databases. Finally, we searched the bibliographies of all identified articles. Our most recent search was conducted on May 28, 2018. We acknowledge that the language restriction (English only) of the search and not having access to the body of Vietnamese medical literature and databases will give us an incomplete perspective into the country's neurosurgical infrastructure and public health initiatives.

Using the GBD data, we also abstracted data for death by cause and prevalence of YLD for common neurosurgical pathologies specifically for Vietnam. The pathologies chosen were meningoencephalitis, preterm birth, CNS cancer, stroke, Parkinson disease, epilepsy, low-back and neck pain, neural tube defects, and road injuries. For comparison purposes, we also included cause-attributable death and YLD data for the chosen neurosurgical diseases from representative nations close to World Bank GDP per capita quartile estimates for low income (Tanzania), middle income (China), and upper income (Japan, the US) (https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?year_high_desc=false). Examination of several similar nations in each stratum showed a relative consistency in burden of neurosurgical disease as measured by YLD.

Results

Despite an exhaustive search, we did not find many articles in the English language literature specifically addressing neurosurgery in Vietnam. Nevertheless, the articles we did find appeared to confirm our hypothesis that it would be challenging for a highly specialized field such as neurosurgery to keep pace with Vietnam's rapid economic growth and the resultant disease burden shifts.

In 1997, Rosenfeld and Xuan wrote:³⁸

...the conditions of neurosurgery endured by our neurosurgical colleagues in Vietnam are far inferior to those in the developed world, particularly in terms of training, educational aids, investigative and operating room equipment, and post-operative and rehabilitative care. The recent formation of the Neurosurgical Society of Vietnam will help to improve these conditions, but help and encouragement from neurosurgeons in the developed world will also be of much value. The instigation of preventative strategies will likely make a significant impact on the health costs of neurotrauma in Vietnam.

The interventions we found enacted in the 20 years since tended to be ultra-low-cost and aimed at primary prevention of risk factors for neurosurgical disease or focused on the transference of self-sustainable technical skills from urban- to rural-based medical personnel. These interventions specific to Vietnam are analogous to those that have been successful in other regions.^{7,9,10}

Among low-cost interventions aimed at primary prevention, efforts toward the primary prevention of stroke have been focused on diagnosis, prevention, and control of causal risk factors such as hypertension and diabetes, with systematic efforts led toward raising awareness of these conditions through media and toward decentralization of care into the countryside. Efforts aimed at decreasing smoking have been implemented through existing infrastructure, such as buses and schools.^{20,41} In terms of primary prevention of traumatic brain injury, multiple in-

TABLE 2. Comparison of population and number of neurosurgeons for Vietnam, the US, and Japan

Nation	Population (millions)	No. of Neurosurgeons	Neurosurgeons per Capita
Vietnam	94	600	1 per 157,000
US	328	3700	1 per 89,000
Japan	126	7500	1 per 17,000

Population estimates for Vietnam, the US, and Japan were obtained from <https://www.cdc.gov/globalhealth/countries/vietnam/>, <https://www.census.gov/popclock/>, and <https://www.cia.gov/library/publications/the-world-factbook/geos/ja.html>, respectively.

vestigators have found interventions aimed at increasing helmet use successful.^{19,32,36}

Among practices aimed at improving advanced, technical capacity, the Direction of Healthcare Activities (DOHA) program has been developed over the past 50 years to accelerate the transfer of technical skills to community hospitals. While these reforms are considered anecdotally successful and have been described as a model for nations with limited healthcare resources, our search did not detect any reliable systematic assessment of the impact of DOHA activities.⁴³ There are some data to suggest that equipment donation programs can have a positive impact.⁴⁵

As an example of how neurosurgical practice has changed in Vietnam in the 20 years since the original report by Rosenfeld and Xuan, Cho Ray Hospital in Ho Chi Minh City has reported a 46.2% increase in elective neurosurgical cases since 2004.²⁷ This hospital has served as one of Vietnam's leading academic institutions. It has successfully leveraged cooperative programs with other nations.⁴² Nevertheless, overall data are sparse, dominated by descriptive publications and qualitative reports; further efforts are needed to understand how the disproportionate burden of neurosurgical disease is being addressed in Vietnam and other middle-income nations. Additional quantitative analyses are necessary to provide higher-resolution success metrics.

As of 2018, there are more than 600 neurosurgeons in Vietnam, up from roughly 300 in 2008. There are more than 10 universities and academic hospitals that graduate 50–60 surgeons per year (<http://neurosurgery.vn/>). Information about population and number of neurosurgeons for Vietnam, the US, and Japan is presented in Table 2. Additionally, we present the results of our GBD data analyses for cause-attributable death in Table 3 and YLD in Table 4. In terms of cause-attributable death, 21.16% (95% uncertainty interval [UI] 19.18%–23.25%) of deaths in Vietnam were attributable to neurosurgical pathology. These numbers were 10.92% (95% UI 8.66%–14.00%), 23.29% (95% UI 22.28%–24.24%), 10.78% (95% UI 9.83%–11.70%), and 9.97% (95% UI 9.41%–10.54%) in Tanzania, China, Japan, and the US, respectively. In terms of YLD, neurosurgical pathologies accounted for 18.39% (95% UI 14.85%–22.53%) of total YLD in Vietnam, 11.75% (95% UI 8.18%–15.67%) in Tanzania, 19.82% (95% UI 16.42%–23.43%) in China, 21.93% (95% UI 18.55%–25.40%) in Japan, and 16.94% (95% UI 14.80%–19.20%) in the US.

TABLE 3. Death by cause for common neurosurgical pathologies in Tanzania, Vietnam, China, Japan, and the US, calculated using 2016 GBD data

Pathology	Tanzania	Vietnam	China	Japan	US
Meningoencephalitis	2.40 (1.77–3.50)	0.40 (0.32–0.54)	0.11 (0.081–0.15)	0.072 (0.062–0.097)	0.081 (0.071–0.11)
Preterm birth	2.28 (1.56–3.19)	0.56 (0.39–0.77)	0.29 (0.25–0.32)	0.016 (0.014–0.018)	0.25 (0.24–0.27)
Brain cancer	0.20 (0.17–0.25)	0.21 (0.17–0.24)	0.61 (0.55–0.69)	0.19 (0.15–0.21)	0.61 (0.53–0.64)
Stroke	3.77 (3.23–4.33)	15.54 (14.52–16.61)	18.52 (17.94–19.08)	9.08 (8.4–9.72)	6.39 (6.05–6.73)
Parkinson disease	0.091 (0.069–0.12)	0.36 (0.27–0.46)	0.41 (0.32–0.53)	0.81 (0.62–1.06)	0.94 (0.87–1.02)
Epilepsy	0.30 (0.26–0.35)	0.38 (0.32–0.43)	0.13 (0.12–0.15)	0.051 (0.048–0.056)	0.075 (0.072–0.077)
Low-back & neck pain	0	0	0	0	0
Neural tube defects	0.15 (0.071–0.30)	0.037 (0.016–0.072)	0.0045 (0.0037–0.0061)	0.00093 (0.00069–0.0012)	0.016 (0.014–0.018)
Road injuries	1.73 (1.53–1.96)	3.67 (3.17–4.13)	3.22 (3.14–3.31)	0.56 (0.54–0.59)	1.61 (1.56–1.67)
Total	10.92 (8.66–14.00)	21.16 (19.18–23.25)	23.29 (22.28–24.24)	10.78 (9.83–11.70)	9.97 (9.41–10.54)

All data given as percentages (95% UI).

Discussion

In some ways, Vietnam is unique in terms of its impressive neurosurgical burden of disease: cerebrovascular disease is the leading cause of death in this nation of 94 million people, low-back and neck pain is the leading cause of disability, and neurotrauma from motor vehicle accidents is among the highest in the world despite effective intervention.²³

Since 1976, Vietnam has been governed by a single-party government (The Socialist Republic of Vietnam), which already has the organizational infrastructure in place to enact centrally directed efforts to improve neurosurgical capacity and reduce disparities in care. Many economists would consider such a structure advantageous if health-care delivery is a natural monopsony.^{6,34} While cerebrovascular disease has been the leading cause of death there since GBD statistics began in 1990, the absolute increase in stroke-related death since that time is due to a longer-lived population. Indeed, age-adjusted stroke-related mortality has been declining, and improvements have also been made in neurotrauma metrics. These improvements follow public health interventions specifically designed to reduce the burden of stroke and increase helmet use.^{1,20}

In other ways, the changing burden of neurosurgical disease in Vietnam is quite typical of its category of rapidly modernizing, lower-middle-income nations with emerging economies and increasingly longer-lived populations susceptible to neurosurgical pathologies. Other developing nations with unusually high cerebrovascular disease and neurotrauma burdens include Vietnam's neighbors in Southeast Asia and Eastern European countries. Increasing wealth has led to noncommunicable diseases supplanting communicable diseases as leading causes of death and disability worldwide, although this trend is particularly profound in lower-middle-income and middle-income nations;¹⁷ this is compounded by an increased prevalence of preventable risk factors such as hypertension (which increased in Vietnam from < 1% in 1960 to > 25% in 2010) and high rates of smoking (46% in Vietnam compared to 16% in the US) and alcohol consumption following increased access to wealth and global trade (<http://www.who.int/gho/countries/vnm.pdf>).^{8,13,20,22,25,29,31} The overall

effect has been a greater than 100% increase in stroke incidence in low- to middle-income nations worldwide since 1970.¹² Likely stemming from poorly controlled hypertension, a disproportionate share of this stroke burden has been shown to be related to hemorrhagic stroke, a deadlier stroke subtype compared with ischemic stroke.^{2,14,37,46} While greater access to public health and primary care can ameliorate these risk factors,³⁰ at the same time, there is increased demand for specialty care in treating acute conditions that can no longer be prevented.

Historically, wealthier nations have adopted a “barbell strategy” for public health, with simultaneous public investments in low-cost primary prevention and in highly technical specialty care. Developing nations such as Vietnam have likewise enacted policies incorporating both low-cost, primary prevention of neurosurgical diseases and transference of highly technical specialized skill sets. The emerging market economies are able to learn from the trial-and-error processes that many developed nations underwent to enact interventions that have been proven to be efficacious and cost-effective, such as blood pressure monitoring and helmet use.³⁵

In terms of the neurosurgical burden of disease and pathologies represented in Vietnam and comparison nations in our data analysis, middle-income nations (including Vietnam as a lower-middle-income nation and China as an upper-middle-income nation) had the highest overall burden of neurosurgical disease as measured by cause-attributable death. In terms of YLD, these nations trailed only Japan, although this exception disappears when only cranial pathologies are examined.³ More than two-thirds of deaths attributable to neurosurgical pathologies in these middle-income nations were due to stroke; in comparison, death attributable to stroke was 35% of death attributable to neurosurgical causes in Tanzania, 84% in Japan, and 64% in the US. This relationship between national income and neurosurgical pathology, and the relationship between national income and stroke, in particular, are interesting findings that should be explored in more detail. Based on our analysis, we would hypothesize that an “inverse J curve” exists for the neurosurgical burden of disease worldwide, with middle-income nations having the highest burden.

TABLE 4. Percentage of total YLD for common neurosurgical pathologies in Tanzania, Vietnam, China, Japan, and the US, calculated using 2016 GBD data

Pathology	Tanzania	Vietnam	China	Japan	US
Meningoencephalitis	0.87 (0.71–1.06)	0.55 (0.45–0.76)	0.39 (0.28–0.48)	0.083 (0.061–0.19)	0.041 (0.035–0.048)
Preterm birth	0.58 (0.39–0.88)	1.25 (0.90–1.73)	0.83 (0.58–1.20)	0.37 (0.26–0.52)	0.79 (0.55–1.09)
Brain cancer	0.0044 (0.0035–0.0055)	0.0051 (0.0039–0.0061)	0.025 (0.021–0.029)	0.017 (0.013–0.020)	0.018 (0.016–0.021)
Stroke	0.31 (0.23–0.39)	1.69 (1.32–2.06)	4.28 (3.31–5.24)	2.85 (2.22–3.47)	2.03 (1.64–2.42)
Parkinson disease	0.018 (0.013–0.025)	0.085 (0.063–0.11)	0.12 (0.089–0.16)	0.17 (0.13–0.23)	0.19 (0.16–0.22)
Epilepsy	1.9 (0.43–3.82)	1.31 (0.41–2.45)	0.72 (0.51–0.96)	0.33 (0.23–0.46)	0.69 (0.48–0.93)
Low-back & neck pain	7.03 (5.86–8.20)	12.14 (10.63–13.72)	11.63 (10.17–13.13)	16.69 (14.52–18.75)	11.72 (10.77–12.65)
Neural tube defects	0.39 (0.30–0.48)	0.12 (0.092–0.14)	0.10 (0.084–0.12)	0.11 (0.09–0.13)	0.11 (0.093–0.13)
Road injuries	0.65 (0.51–0.81)	1.24 (0.98–1.55)	1.72 (1.38–2.11)	1.31 (1.03–1.63)	1.35 (1.06–1.69)
Total	11.75 (8.18–15.67)	18.39 (14.85–22.53)	19.82 (16.42–23.43)	21.93 (18.55–25.40)	16.94 (14.80–19.20)

All data given as percentages (95% UI).

While back pain was proportionally the largest neurosurgical pathology contributing to YLD, ratios were similar across nations, suggesting that back pain plagues the rich and poor alike. Finally, one-fifth of both cause-attributable death and YLD was associated with neurosurgical pathologies in both Vietnam and China. This is a large number that compels neurosurgical and public health intervention to address the causes and effects of these diseases.

As part of the resident training curriculum, our chief resident and several attendings spend time annually at several major hospitals in Vietnam. Through an exchange, Vietnamese bác sĩ (doctors) reciprocally also spend educational time in the US. The neurosurgical teams maintain e-mail communication throughout the year to discuss difficult cases and exchange neurosurgical ideas; this experience has given us some anecdotal support for the data discussed here.

Conclusions

Vietnam and other middle-income nations continue to assume a global burden of disease profile that ever more closely resembles that of developed nations, with particular cerebrovascular, neurotrauma, and spinal disease burdens. This has led to exponentially increased demand for neurosurgeons worldwide. Efforts at addressing these shifting disease demographics have benefitted from the existing public health literature and have focused largely on both primary prevention and dissemination of advanced technical knowledge and equipment. Further efforts are needed to better characterize and address this shifting disease burden in the developing world, including international partnerships similar to GBD but with neurosurgical focus. Middle-income nations appear to be especially plagued by increases in neurosurgical pathology that are outpacing the training of neurosurgeons.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Carr, Mathkour, Dumont. Acquisition of data: Carr, Kahn, Biro, Bui. Analysis and interpretation of data: Carr. Drafting the article: Carr. Critically revising the article: Kahn, Mathkour, Biro, Bui, Dumont. Reviewed submitted version of manuscript: all authors. Statistical analysis: Carr. Administrative/technical/material support: Kahn, Mathkour, Biro, Bui, Dumont. Study supervision: Biro, Bui, Dumont.

Correspondence

Christopher Carr: Tulane Medical Center, New Orleans, LA. ccarr6@tulane.edu.