IHE Report

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Prevalence of dysphagia and economic burden of aspiration pneumonia in patients with stroke or head and neck cancer

Prepared by:

Thomas Lo, M Clin Epi, PhD

Jeff Round, PhD

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Corresponding Author

Please direct any inquiries about this report to Jeff Round, jround@ihe.ca.

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Acronyms and abbreviations

AIS	acute ischemic stroke
AP	aspiration pneumonia
CAD	Canadian dollar
CCI	Canadian Classification of Health Interventions
CMG+	case mix group
DAD	Discharge Abstract Database
ED	emergency department
HNC	head and neck cancer
HPV	human papillomavirus
ICD	International Classification of Diseases
ICH	intracerebral hemorrhage
ICU	intensive care unit
IQR	interquartile range
NACRS	National Ambulatory Care Reporting System
NCME	nasal cavity and middle ear
SD	standard deviation

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Background

Studies that examine the burden of dysphagia are scant; there was an incentive to study the burden of dysphagia using large, population-based administrative data. However, identifying dysphagia cases in the administrative data may be unreliable because dysphagia is underdiagnosed.[1, 2] González-Fernández et al. assessed the accuracy of dysphagia diagnosis in patients with stroke in the hospital data and found that it has a poor sensitivity of 23%, indicating dysphagia is undetected 77% of the time.[3]

Aspiration pneumonia (AP) is strongly associated with dysphagia.[1] It is a serious acute complication of dysphagia,[4, 5] and is the main driver of hospitalization and healthcare cost for patients with dysphagia.[5, 6] Aspiration pneumonia has previously been studied using administrative health data. This study examined the economic burden of aspiration pneumonia using Alberta's data using a similar case-definition algorithm. Two cohorts of patients were identified and followed longitudinally because they had a higher risk of dysphagia and AP;[1, 8, 9] these cohorts were patients with stroke and patients with head and neck cancer (HNC).

Study objectives

This study examined the prevalence of dysphagia and the economic burden of AP in patients who had stroke or HNC. Because tube feeding is recommended in patients that are at a high risk of dysphagia and/or malnutrition, placement of feeding tubes was also examined as an outcome in the two cohorts of patients.

The specific aims of this study were to estimate:

a) the proportion of patients who had a diagnosis of dysphagia;
b) the proportion of patients who had feeding-tube placement;
c) the proportion of patients who had AP;
d) the incidence of AP among these patients; and
e) the cost of hospitalization of AP in these patients.

Methods

This is a retrospective cohort study utilizing Alberta's administrative health data from the calendar years of 2008 to 2018 inclusively. Two cohorts (*cohort A* = patients with stroke; *cohort B* = patients with HNC) were identified and followed longitudinally over the observation period.

Data sources

The main sources of data were: the National Ambulatory Care Reporting System (NACRS), which contains information from hospital/community-based ambulatory care including day surgeries, outpatient clinics, and emergency department (ED) visits; the Discharge Abstract Database (DAD), which contains diagnosis and procedure information about all acute care hospitalizations; the Alberta Practitioner Claims database, which provides information on reimbursement claims made by physicians for services provided to the patients; and the Alberta cancer registry database, which provides cancer diagnosis and treatment information.

Cohort definitions

Cohort A: Patients with stroke

Cohort A consisted of patients with first-diagnosed acute stroke at the ED (ambulatory care NACRS data) and/or inpatient care (DAD data). The included stroke types were acute ischemic stroke (AIS) and intracerebral hemorrhage (ICH). Incident stroke cases were identified based on a revised algorithm (restricted to the stroke types below) used by Alberta Health and in the Interactive Health Data Application (IHDA), where the most responsible diagnosis code in DAD and NACRS for each record was scanned.[10] The specific stroke types were AIS and ICH only. The respective International Classification of Diseases (ICD-10) codes were:[10]

- H341, H342, I63, I64 for AIS; and
- I61 for ICH.

Based on the above algorithm, we identified stroke patients that had service episode start dates in the 2014 calendar year. We used the five years of preceding records (i.e., DAD and/or ED data as far back as 1 January 2009) to ascertain first-diagnosed cases. It was suggested that a five-year clearance period would include 97% of true first-diagnosed stroke cases.[11] Exclusion criteria of the stroke cohort include patients who were younger than 18 years of age in 2014, not presented at the ED or admitted to the hospital, other types of cerebrovascular disease (e.g., transient ischemic attack), or had HNC diagnosed in the follow-up (observation) periods. Patients who had more than one acute stroke incident were included; the first incident was used as the index diagnosis. These patients were followed for up to three years from the index date (i.e., the date when stroke was first diagnosed) or until death.

Cohort B: Patients with HNC

Cohort B consisted of patients with HNC identified from the cancer registry. These patients were diagnosed with HNC from the calendar year of 2008 to 2012, based on the diagnosed date. Patients were identified using the ICD-O topographical (ICD-0-3) codes. The relevant diagnostic codes are listed in Appendix A. The exclusion criteria of the HNC cohort were patients younger than 18 years of age. HNCs were also categorized into: *oral* (C00-C14), *nasal cavity and middle ear* (C30), and *larynx* (C32); or *HPV associations*. HPV association was categorized into *high*, *moderate*, and *other* (see Appendix B).[12] These patients were followed for up to five years or until death.

Outcome variables

The main health outcomes in both cohorts were dysphagia, feeding-tube placement, and AP.

Dysphagia

The ED data (within NACRS), inpatient (DAD) data, and the physician claims data were scanned for dysphagia diagnosis. The identification of patients with dysphagia was based on ICD-10 and/or ICD-9 codes; these codes are summarized in Appendix A.

Feeding-tube placement

Also known as *enteral feeding*, tube feeding is the delivery of nutrition directly into the stomach or small intestine; it is a means to provide nutrients (i.e., protein, carbohydrate, fat, minerals, vitamins, and water) to individuals (e.g., post-stroke and patients with HNC) who cannot obtain nutrition entirely by mouth. To determine patients who had feeding-tube placement, the NACRS and DAD databases

were used. The relevant Canadian Classification of Health Interventions (CCI) procedure codes for gastrostomy were: 1NF53BTQB, 1NF53BTTS, 1NF53DAQB, 1NF53DATS, or 1NF53HATS. The relevant codes for jejunostomy (post-pyloric tubes) were: 1NK53BTTS, 1NK53DATS, or 1NK53HATS.[12] The CCI codes are summarized in Appendix A.

Aspiration pneumonia

Because AP is an acute condition and a major driver of hospitalization and healthcare cost in patients with dysphagia,[4-6] it was assumed that the majority of patients would have visited the hospitals. The ICD-10 codes of J690, J691, or J698 were examined in both the DAD and ED data in the NACRS to identify AP presented at hospitals.[7, 13] Physician claims data were not included in the case identification algorithm.

The cost of hospitalization for AP was estimated. Here, the unit of analysis was the AP incident. Any patient in the cohorts can have multiple AP incidents during the observation period. The start and end of an AP incident were defined based on three criteria:

- an AP diagnostic code in the hospital data that indicates the beginning of an incident;
- the duration of one AP incident cannot be shorter than 14 days; and
- an incident ends when there was no subsequent record, within 14 days, with an AP diagnostic code.

The 14-day criterion conforms to the length of antibiotic treatment (e.g., clindamycin or macrolides), which can be as long as 14 days.[14] Detailed information about the definition of an incident of AP can be found in Appendix C.

Hospitalization costs of AP

Costs per incident of AP were estimated from the payer's (Government of Alberta's) perspective. They included the direct costs of care of patients who visited the ED and/or were admitted to the hospital (i.e., inpatient cost). ED visit and inpatient costs included all costs attributable to the care of the patients, including nursing, laboratory, diagnostic imaging, drug, and supply costs. The cost of hospitalization also included the services provided by physicians that were recorded in the claims data. However, these costs may be attributable to the care of AP and/or comorbidities. The costs of ED visits (i.e., ambulatory care) and inpatient care were estimated using a top-down approach based on the case mix group (CMG+) methodology. The costs of physician services were estimated based on the actual amount paid for the services claimed. Cost estimation was based on the latest CMG+ methodology and data between the fiscal years of 2013/14 and 2017/18. All costs were adjusted to 2018 CAD using the consumer price index.

Other variables

Other variables included the demographic characteristics and health conditions of the patients. Demographic characteristics included sex, age, and household income. The age groups were categorized into *young-adults* (18 to 39 years), *middle-aged adults* (40 to 64 years), *young-old* (65 to 84 years), and *old-old* (85 years and older). The median household income of the dissemination areas in Alberta was estimated based on the 2016 Census data and categorized into eight income levels. Health conditions included multi-morbidity, intensive care unit (ICU) admittance during an incident of AP, and mortality. Multi-mortality was measured using the Charlson Comorbidity Index.[15]

Statistical analysis

Characteristics of the cohorts are summarized using the mean (and standard deviation [SD]) for continuous variables, and proportion for categorical variables.

The prevalence of dysphagia, enteral feeding, and AP were calculated for the two cohorts. Incidence rates of AP were calculated for the observation period.

Hospitalization cost (the sum of ED visit, inpatient, and physician costs) per AP incident calculations included the mean, SD, median, and interquartile range (IQR).

Because the cost distribution was severely positively skewed, quantile regression models were used to examine the association between costs and explanatory variables. Quantile regression does not assume normality or homoskedasticity of the distribution of cost. Explanatory variables included in the regression models were age, sex, median household income, number of comorbidities, dysphagia status, feeding tube type, stroke type (cohort A only), and cancer type and HPV association (cohort B only). Statistical significance was defined as $p<0.05$.

Results

Cohort characteristics

There were 3,573 patients with first-ever stroke identified from 2014 data. The majority (88.9%) had AIS. The sex and age distributions of the patients with stroke are illustrated in Table 1.

Table 1: Characteristics of patients with stroke (N=3,573)

	n	%
Stroke type		
AIS	3,176	88.9%
ICH	397	11.1%
Sex		
Female	1,653	46.3%
Male	1,920	53.7%
Age group		
18–39 years	138	3.9%
40–64 years	1,086	30.4%
65–84 years	1,679	47.0%
≥85 years	670	18.8%

AIS: acute ischemic stroke; ICH: intracerebral hemorrhage

There were 2,169 patients with HNC identified from the cancer registry from 2008 to 2012 inclusively. The majority (78.9%) had oral cancer. The characteristics of the patients with HNC are illustrated in Table 2.

Table 2: Characteristics of patients with HNC (N=2,169)

	n	%
HNC type		
Larynx	388	17.9%
NCME	70	3.2%
Oral	1,711	78.9%
Sex		
Female	1,019	47.0%
Male	1,150	53.0%
Age group		
18–39 years	99	4.6%
40–64 years	1,170	53.9%
65–84 years	784	36.2%
≥85 years	116	5.4%

NCME: nasal cavity and middle ear

Outcomes

Outcome 1: Dysphagia

In the patients who had the first-ever stroke in 2014, 554 had been diagnosed with dysphagia within the three-year follow-up period. Among these patients, the median time from stroke to diagnosed dysphagia was 13 days (IQR=0–121). Patients with dysphagia were more likely to be male and/or were older. The characteristics of patients with stroke, with and without dysphagia, are shown in Table 3.

Table 3: Characteristics of patients with stroke, with and without dysphagia

	With dysphagia n=554	Without dysphagia n=3,019	Chi-square test (*p*-value)
Stroke type			0.2176
AIS	43.9%	46.7%	
ICH	56.1%	53.3%	
Sex			0.0156*
Female	85.9%	89.4%	
Male	14.1%	10.6%	
Age group			<0.0001*
18–39 years	1.8%	4.2%	
40–64 years	24.2%	31.5%	
65–84 years	51.1%	46.2%	
≥85 years	22.9%	18.0%	

AIS: acute ischemic stroke; ICH: intracerebral hemorrhage

Among the patients with HNC in cohort B, 1,052 had dysphagia within the five-year follow-up period. The median time from HNC to diagnosed dysphagia was longer (compared to the patients with stroke) at 90 days (IQR=55–198). These patients with dysphagia were less likely to have nasal cavity and middle ear (NCME) cancer. The characteristics of patients with HNC, with and without dysphagia, are shown in Table 4.

Table 4: Characteristics of patients with HNC, with and without dysphagia

	With dysphagia n=1,052	Without dysphagia n=1,117	Chi-square test (*p*-value)
HNC type			0.0147*
Larynx	18.2%	17.6%	
NCME	2.1%	4.3%	
Oral	79.8%	78.1%	
Sex			0.6814
Female	47.4%	46.6%	
Male	52.6%	53.5%	
Age group			<0.0001*
18–39 years	3.0%	6.1%	
40–64 years	57.3%	50.8%	
65–84 years	35.8%	36.4%	
≥85 years	3.9%	6.7%	

NCME: nasal cavity and middle ear

Outcome 2: Feeding-tube placement

In the stroke cohort, 100 patients had a feeding-tube placement within the three-year follow-up period. Among these patients, the median time from stroke to feeding-tube placement was one day (IQR=0–52 days). Patients who had tube feeding were more likely to have had intracerebral hemorrhage (18.0% vs. 10.9%). The characteristics of patients with stroke, with and without feeding-tube placement, are illustrated in Table 5.

Table 5: Characteristics of patients with stroke, with and without feeding-tube placement

	With feeding-tube n=100	Without feeding-tube n=3,473	Chi-square test (*p*-value)
Stroke type			0.0262*
AIS	82.0%	89.1%	
ICH	18.0%	10.9%	
Sex			0.7971
Female	45.0%	46.3%	
Male	55.0%	53.7%	
Age group			0.0929
18–39 years	2.0%	3.9%	
40–64 years	30.0%	30.4%	
65–84 years	57.0%	46.7%	
≥85 years	11.0%	19.0%	

AIS: acute ischemic stroke; ICH: intracerebral hemorrhage

In the HNC cohort, 492 patients had a feeding-tube placement within the five-year follow-up period. The median time from HNC diagnosis to feeding-tube placement was 98 days (IQR=50–199 days). Patients who had feeding-tube placement were less likely to have NCME cancer, but were older compared to the patients without feeding-tube placement. The characteristics of patients with HNC with and without feeding-tube placement are shown in Table 6.

Table 6: Characteristics of patients with HNC, with or without feeding-tube placement

	With feeding-tube n=492	Without feeding-tube n=1,677	Chi-square test (*p*-value)
HNC type			0.0026*
Larynx	18.3%	17.8%	
NCME	0.8%	3.9%	
Oral	80.9%	78.3%	
Sex			0.4631
Female	45.5%	47.4%	
Male	54.5%	52.6%	
Age group			0.0017*
18–39 years	3.9%	4.8%	
40–64 years	57.3%	53.0%	
65–84 years	36.8%	36.0%	
≥85 years	2.0%	6.3%	

NCME: nasal cavity and middle ear

Outcome 3: Aspiration pneumonia

In the stroke cohort, 141 patients (3.9%) had AP presented at a hospital within the follow-up period. The median time from stroke to diagnosed AP was 90 days (IQR=0–528 days). The patients who had diagnosed AP were more likely to be older. The characteristics of patients with stroke, with and without diagnosed AP, are illustrated in Table 7.

Table 7: Characteristics of patients with stroke, with and without aspiration pneumonia

	With aspiration pneumonia n=141	Without aspiration pneumonia n=3,432	Chi-square test (*p*-value)
Stroke type			0.3161
AIS	91.5%	88.8%	
ICH	8.5%	11.2%	
Sex			0.2828
Female	41.8%	46.5%	
Male	58.2%	53.6%	
Age group			0.0013*
18–39 years	0.7%	4.0%	
40–64 years	19.2%	30.9%	
65–84 years	53.9%	46.7%	
≥85 years	26.2%	18.4%	

AIS: acute ischemic stroke; ICH: intracerebral hemorrhage

Among the patients with stroke who had AP, 167 incidents were identified. The mean number of AP incidents per patient with stroke was 1.22 (SD=0.74). The majority of these patients (86.86%) had only one AP incident. The estimated mean hospital length of stay per AP incident was 26.54 (SD=74.09) days. At the time of the incident, patients with stroke had an average CCI score of 2.18 (SD=1.96). The most common comorbidity group was cerebrovascular diseases, followed by diabetes with complications. The five most common comorbidity groups are illustrated in Table 8.

Table 8: Top five comorbidity groups in patients with stroke diagnosed at an aspiration pneumonia incident

Comorbidity	%
Cerebrovascular disease	43.7%
Diabetes with complications	22.8%
Chronic pulmonary disease	18.6%
Congestive heart failure	17.4%
Dementia	16.2%

In the HNC cohort, 146 patients (6.7%) had AP within the follow-up period. The median time from HNC to diagnosed AP was 334 days (IQR=129–843 days). About 50% of patients who had AP were in the 65 to 84 years age groups. In contrast, the majority of HNC patients without AP (approximately

60%) were under 65 years old. The characteristics of patients with HNC, with and without diagnosed AP, are shown in Table 9.

Table 9: Characteristics of HNC patients, with and without aspiration pneumonia

	With aspiration pneumonia n=146	Without aspiration pneumonia n=2023	Chi-square test (*p*-value)
HNC type			0.1068
Larynx	23.3%	17.5%	
NCME	1.4%	3.4%	
Oral	75.3%	79.1%	
Sex			0.1062
Female	53.5%	46.5%	
Male	46.6%	53.5%	
Age group			0.0002*
18–39 years	0.0%	4.9%	
40–64 years	43.8%	54.7%	
65–84 years	50.7%	35.1%	
≥85 years	5.5%	5.3%	

NCME: nasal cavity and middle ear

Among patients with HNC with AP, 168 AP incidents were identified in the hospital data. The mean number of incidents per patient was 1.18 (SD=0.50). The majority of these patients (85.9%) had only one AP incident. The estimated mean hospital length of stay per AP incident was 21.10 (SD=34.58) days. At the time of the incident, patients with HNC had an average CCI score of 2.14 (SD=2.75) (*note*: Cancer and carcinoma metastasis groups of diseases were excluded from the CCI calculation.) The most common comorbidity group was chronic pulmonary diseases, followed by diabetes without complications. The five most common comorbidity groups are illustrated in Table 10.

Table 10: Top five comorbidity groups in patients with HNC diagnosed at an aspiration pneumonia incident

Comorbidity	%
Chronic pulmonary disease	22.6
Diabetes without complications	11.9
Diabetes with complications	7.7
Congestive heart failure	6.6
Myocardial infarction	5.4

Summary of outcomes

While 17.5% of patients with stroke had diagnosed dysphagia, feeding-tube placement, and/or AP, 53.3% of patients with HNC had one or more of these conditions. The results of the three outcomes for both cohorts are summarized in Table 11.

Table 11: Prevalence of dysphagia, feeding-tube placement, and/or aspiration pneumonia in patients with stroke or HNC

	Patients with stroke	Patients with HNC
Dysphagia		
n (%)	554 (15.5%)	1,052 (48.5%)
Female	13.3%	23.0%
Male	2.2%	25.5%
18–39 years	0.3%	1.4%
40–64 years	3.8%	27.8%
65–84 years	7.9%	17.4%
≥85 years	3.6%	1.9%
Feeding-tube placement		
n (%)	100 (2.8%)	492 (22.7%)
Female	1.3%	10.3%
Male	1.5%	12.4%
18–39 years	0.1%	0.9%
40–64 years	0.8%	13.0%
65–84 years	1.6%	8.3%
≥85 years	0.3%	0.5%
Aspiration pneumonia		
n (%)	141 (3.9%)	146 (6.7%)
Female	1.6%	3.6%
Male	2.3%	3.1%
18–39 years	0.0%	0.0%
40–64 years	0.8%	3.0%
65–84 years	2.1%	3.4%
≥85 years	1.0%	0.4%

Note: Patients with stroke were followed three years; patients with HNC were followed five years.

Hospitalization costs of AP and comorbidities

The mean hospitalization cost (the sum of ED visit, inpatient, and physician costs) of an AP incident in patients who had stroke was estimated at $32,219 (2018 CAD). Cost distribution was severely positively skewed; the median (IQR) cost per incident was estimated at $12,063. Inpatient cost (including nursing, laboratory, diagnostic imaging, drug, and supply costs) was the biggest component (89.2%) of total hospitalization costs, followed by physician costs (9.7%) and ED costs (1.1%). In Alberta, AP in patients with stroke cost the government approximately $1.8 million per year. Descriptive statistics of hospitalization cost and the component breakdown are shown in Table 12.

Table 12: Costs of hospitalization for aspiration pneumonia in patients with stroke

Hospitalization cost component	Cost (2018 CAD)	SD or IQR
Emergency department		
Mean (SD)	$367	(481)
Median (IQR)	$0	(0–817)
Inpatient		
Mean (SD)	$28,725	(67,835)
Median (IQR)	$8,378	(2,346–26,376)
Physician		
Mean (SD)	$3,127	(4,765)
Median (IQR)	$1,516	(575–3,637)
Total		
Mean (SD)	$32,219	(67,653)
Median (IQR)	$12,063	(5,550–30,864)

Note: Costs may be attributable to the treatment of AP and/or comorbidities.

IQR: interquartile range; SD: standard deviation

The mean hospitalization cost for AP in the HNC cohort was estimated at $21,828 (2018 CAD); the median cost per incident was $8,794. Similar to that in the stroke cohort, inpatient cost was the biggest component (85.0%) of the total cost, followed by physician costs (13.0%) and ED costs (2.0%). Aggregated at the population level, AP incidents in patients with HNC cost the Alberta government over $730,000 annually. Descriptive statistics of the cost breakdown can be found in Table 13.

Table 13: Costs of hospitalization for aspiration pneumonia in patients with HNC

Hospitalization cost component	Cost (2018 CAD)	SD or IQR
Emergency department		
Mean (SD)	$445	(513)
Median (IQR)	$0	(0–833)
Inpatient		
Mean (SD)	$19,320	(29,704)
Median (IQR)	$7,178	(1,775–22,938)
Physician		
Mean (SD)	$2,965	(3,387)
Median (IQR)	$1,121	(347–2,027)
Total		
Mean (SD)	$21,828	(32,131)
Median (IQR)	$8,794	(2,902–24,590)

Note: Costs may be attributable to the treatment of AP and/or comorbidities.

IQR: interquartile range; SD: standard deviation

Regression analysis results show that none of the included independent variables were statistically significantly associated with hospitalization cost in either the models. Nonetheless, in the regression model that included patients with stroke, the signs of the coefficients suggest a positive relationship between cost and the oldest age group, lower income levels, AIS stroke type (relative to ICH), feeding-tube placement, number of comorbidities, and/or mortality (see Table 14). Results also suggest that costs were negatively associated with female sex, dysphagia diagnosis, and/or ICU admittance. However, statistical tests were not significant for any explanatory variables.

In the regression model that included patients with HNC, the signs of the coefficients suggest that lower age groups, higher income levels, cancer in NCME (relative to oral cancer), HPV association, tube feeding, and ICU admittance were positively related to costs, while female sex, cancer in the larynx, dysphagia diagnosis, and number of comorbidities were negatively related to costs (see Table 15).

Table 14: Median regression results for hospitalization costs of aspiration pneumonia incidents in patients with stroke

Variable	Coefficient	95% CI	*p*-value
Sex			
Female	−5,013	−11,625, 1,599	0.1362
Age group			
18–39	−5,409	−71,104, 60,287	0.8709
40–64	−5,159	−16,118, 5,800	0.3536
65–84	−4,787	−16,679, 7,105	0.4274
≥85 (ref.)			
Income level			
>200,000 (ref.)			
150,000–200,000	−1,811	−15,042, 11,419	0.787
120,000–150,000	−2,769	−14,613, 9,075	0.6447
90,000–120,000	1,085	−14,060, 16,231	0.8875
60,000–90,000	2,792	−10,463.63, 16,048	0.6777
30,000–60,000	731	−18,882, 20,344	0.9414
<30,000	2,182	−28,525, 32,888	0.8885
Stroke type			
ICH (ref.)			
AIS	3,644	−6,994, 14,282	0.4994
Other			
Dysphagia	−451	−13,030, 12,128	0.9435
Tube feeding	12,809	−56,562, 82,180	0.7156
No. comorbidities	2,233	−614, 5,080	0.1233
ICU admitted	−144	−10,887, 10,600	0.9789
Mortality	1,594	−86,940, 90,128	0.9717

AIS: acute ischemic stroke; CI: confidence interval; ICH: intracerebral hemorrhage; ICU: intensive care unit

Table 15: Median regression results for hospitalization costs of aspiration pneumonia incidents in patients with HNC

Variable	Coefficient	95% CI	*p*-value
Sex			
Female	−3,164	−45,387, 39,059	0.877
Age group			
18–39	NA	NA	NA
40–64	77,003	−41,072, 195,078	0.1882
65–84	75,386	−69,965, 220,736	0.2913
≥85 (ref.)			
Income level			
>200,000 (ref.)			
150,000–200,000	18,012	−90,245, 126,268	0.7315
120,000–150,000	20,132	−79,029, 119,292	0.6757
90,000–120,000	20,841	−67,545, 109,226	0.6273
60,000–90,000	6,661	−94,292, 107,615	0.8916
30,000–60,000	21,718	−109,573, 153,009	0.733
<30,000	21,937	−109,067, 152,940	0.7298
HNC type			
Oral (ref.)			
Larynx	−4,355	−58,949, 50,240	0.8692
NCME	75,177	−124,734, 275,088	0.4409
HPV association			
Low (ref.)			
Moderate	4,764	−78,973, 88,501	0.9065
High	16,809	−53,622, 87,239	0.6231
Other			
Dysphagia	−5,577	−44,036, 32,881	0.7648
Tube feeding	6,681	−28,396, 41,757	0.6946
No. comorbidities	−1,741	−20,944, 17,462	0.8515
ICU admitted	128,272	−16,973, 273,517	0.0802

CI: confidence interval; ICU: intensive care unit; NA: not available; NCME: nasal cavity and middle ear

Limitations of analysis

Because administrative health data were not originally collected for research purposes, there are some limitations in the analysis of this study. Identification of the two cohorts of patients (i.e., with stroke and HNC) and the outcome relied on contacts with the health care system and information in the data (e.g., records of diagnosis). Not all patients with a specific condition, such as dysphagia, have seen a doctor and/or diagnosed. Hence, the prevalence and incidence measures in this study were likely underestimated.

Cost estimates in this study were for AP and comorbidity present at the time of the incidents. Although some precautions (e.g., the use of most responsible diagnosis and diagnosis type) were taken during the ascertainment of AP incidents and costs, because each episode of healthcare contact can associate with multiple diagnoses, it was impossible to allocate the cause of contact (or costs) to one specific condition. Additionally, the follow-up periods were different for the two cohorts; any comparison of results made between the stroke and HNC cohorts must be interpreted with caution.

Several factors might have affected the regression analysis results. While data of the independent variables (in the regression models) were extracted at the individual level, inpatient and ED costs were estimated using a top-down approach based on group averages (CMG+); this approach could have diluted the true variance of costs between patients. In some variables, there might have been too few occurrences (e.g., only three stroke patients died during an AP incident) to yield any statistically significant findings.

Conclusion

The number of first-ever AIS and ICH was 3,573 per year, based on 2014 Alberta data. Administrative health data indicate 15.5% of these patients were diagnosed with dysphagia within a three-year follow-up period, while 17.5% had either dysphagia, tube feeding, and/or AP. Because tube feeding and AP are strongly associated with dysphagia, the number of patients with diagnosed dysphagia was likely underestimated.

About 434 patients were diagnosed with HNC per year between 2008 and 2012 in Alberta. Among these patients, nearly half (48.5%) were diagnosed with dysphagia in a five-year follow up, while 53.3% had either dysphagia, tube feeding, and/or AP.

The hospitalization cost of AP was estimated at $32,219 (2018 CAD) in patients with stroke and $21,828 (2018 CAD) in patients with HNC. When multiplying these costs by the number of AP incidents per year (both stroke and HNC cohorts), the annual costs to the Alberta government were $1.8 million and $730,000 respectively.

The regression analysis did not find any statistically significant explanatory variable of cost in this study.

Appendix A: Summary of conditions and procedures

Acute stroke

Table A.1: Stroke and associated diagnostic codes

Sub-group	ICD-9-CM	ICD-10-CA
Arterial ischemic stroke (AIS)		
AIS - Retinal vascular occlusion	362.3	H34.1, H34.2
AIS - Occlusion and stenosis of precerebral arteries	433.x1	I63.x
AIS - Occlusion of cerebral arteries	434.x1	I64.x
AIS - Acute, but ill-defined cerebrovascular disease	436	NA
Intracerebral hemorrhage (ICH)	431.x	I61.x
Subarachnoid hemorrhage (SAH)	430.x	I60.x

Head and neck cancers

Table A.2: Head and neck cancers and associated two-digit ICD-O-3 codes

Sub-group	ICD-O-3 Topographical	AHS cancer type
Lip	C00	Oral
Base of tongue	C01	Oral
Other and unspecified parts of tongue	C02	Oral
Gum	C03	Oral
Floor of month	C04	Oral
Palate	C05	Oral
Other and unspecified parts of mouth	C06	Oral
Parotid gland	C07	Oral
Other and unspecified major salivary glands	C08	Oral
Tonsil	C09	Oral
Oropharynx	C10	Oral
Nasopharynx	C11	Oral
Pyriform sinus	C12	Oral
Hypopharynx	C13	Oral
Other and ill-defined sites in lip, oral cavity, and pharynx	C14	Oral
Nasal cavity and middle ear	C30	NCME
Larynx	C32	Larynx

Dysphagia and aspiration pneumonia

Table A.3: Dysphagia and aspiration pneumonia and associated diagnostic codes

Condition	ICD-9-CM	ICD-10-CA
Dysphagia	787.2	R13.0, R13.2, R13.8
Aspiration pneumonia	507.0, 507.1, 507.8	J69.0, J69.1, J69.8

Feeding-tube placement

Table A.4: Feeding-tube placement and associated procedure codes

Sub-group	CCI
Gastrostomy (G-tubes)	1.NF.53.^^, 1.NF.53.BT-TS, 1.NF.53.BT-QB, 1.NF.53.DA-TS, 1.NF.53.DA-QB, 1.NF.53.HA-TS
Jejunostomy (J-tubes)	1.NK.53.^^, 1.NK.53.BT-TS, 1.NK.53.DA-TS, 1.NK.53.HA-TS

Appendix B: Association between head and neck cancer and human papillomavirus infection

Table B.1: Association between head and neck cancer (based on 3-digit ICD-O-3 codes) and human papillomavirus infection

HPV association	ICD-O-3 codes
High	C01.9, C02.4, C05.1, C05.2, C09.0-10.3, C10.8-10.9, C14.0, C14.2
Moderate	C00.3-00.4, C02.0-C02.3, C02.9-C03.1, C03.9-C04.1, C04.9-C05.0, C05.9-C06.2, C06.9
Low	C11.0-C13.9, C30.0, C32.0-C32.9

Adapted from: Johnson-Obaseki et al. (2012)[16]

HPV: human papillomavirus

Appendix C: Definition of the length of an aspiration pneumonia incident based on administrative data

Length of an AP incident is calculated in days. The start of an incident was marked by a record in the NACRS (ED data only) or DAD data with a most responsible diagnosis (MRDx) or type 1 diagnosis ("a condition that impacted care, i.e. a significant comorbidity, and was present prior to hospital admission") of AP. This is because an AP can be induced by an intervention (e.g., tube feeding) and/or presented after hospital admission. Each hospital record has a start (and end) date; the start date was used to proxy the beginning of an AP incident.

It was assumed an incident of AP cannot be ≤14 days because antibiotic treatment of pneumonia (including AP) can be as long as 14 days. For example, if data indicated a patient visited the ED with a diagnosis of AP and was discharged home the same day without a hospital admission, then the length of this AP incident is 14 days. The length of an AP incident can also be different from the length the patient spent at the hospital because a person can be discharged (after hospitalization) home before the end of their pharmacotherapy for AP. Though the person can remain in a hospital for other treatments, the end of an incident was marked by discharge date of hospital record (ED or inpatient) due to data limitations, provided that there has been ≥14 days since the beginning of the incident.

An incident did not necessary end at discharge (home) of the same hospital stay. Instead, it ended when the data indicated the patient has no subsequent AP diagnosis and/or the next record was >14 days. The 14-day cut-off was used because it was assumed that recovery from an AP took at least 14 days.

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Author contributions

Thomas Lo contributed to study conception and design, data collection and analysis, interpretation, and revisions of the report, and approved the final version.

Jeff Round contributed to critical review of the report, and approved the final version.

INSTITUTE OF
HEALTH ECONOMICS
ALBERTA CANADA

Institute of Health Economics
1200 – 10405 Jasper Avenue
Edmonton AB Canada T5J 3N4
Tel. 780.448.4881 Fax. 780.448.0018
info@ihe.ca

www.ihe.ca