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Rates of dysphagia related diagnoses in long-term survivors of head and neck cancers

Alana Aylward, MD¹, Sarah Abdelaziz, MStat¹, Jason P. Hunt, MD¹, Luke O. Buchmann, MD¹, Richard B. Cannon, MD¹, Kerry Rowe, PhD², John Snyder, MStat², Yuan Wan, MSCE³, Vikrant Deshmukh, JD/PHD⁴, Michael Newman, MS⁴, Alison Fraser, MSPH³, Ken Smith, PHD³, Kim Herget, MStat⁵, Shane Lloyd, MD⁶, Ying Hitchcock, MD⁶, Mia Hashibe, PHD/MPH⁷, Marcus M. Monroe, MD¹

¹Department of Otolaryngology-Head and Neck Surgery, University of Utah School of Medicine and Huntsman Cancer Institute, Salt Lake City, UT

²Intermountain Healthcare, Salt Lake City, UT

³Pedigree and Population Resource, Population Sciences, Huntsman Cancer Institute, Salt Lake City, UT

⁴University of Utah Health Sciences Center, Salt Lake City, UT

⁵Utah Cancer Registry, University of Utah, Salt Lake City, UT

⁶Department of Radiation Oncology, Radiation Oncology, University of Utah School of Medicine and Huntsman Cancer Institute, Salt Lake City, UT

⁷Department of Family and Preventive Medicine, Division of Public Health, University of Utah School of Medicine, Salt Lake City, UT

Abstract

OBJECTIVE: To estimate long-term prevalence of new dysphagia-related diagnoses in a large cohort of head and neck cancer survivors.

STUDY DESIGN: Retrospective cohort

SETTING: Population-based

SUBJECTS AND METHODS: 1901 adults diagnosed with head and neck cancer between 1997 and 2012 with at least 3 years of follow up were compared with 7,796 controls matched for age, sex and birth state. Prevalence of new dysphagia-related diagnoses and procedures and hazard ratio compared to controls were evaluated in patients 2–5 years and 5 years and beyond after diagnosis. Risk factors for the development of these diagnoses were analyzed.

RESULTS: Prevalence of new diagnosis and hazard ratio compared to controls remained elevated for all diagnoses throughout the time periods investigated. The rate of aspiration pneumonia was

Corresponding Author: Marcus M. Monroe, MD, Department of Surgery, Division of Otolaryngology, University of Utah School of Medicine, 50 North Medical Drive, Rm 3C120, Salt Lake City, UT 84132, marcus.monroe@hsc.utah.edu.

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3.13% at 2–5 years increasing to 6.75% at 5 or more years, with hazard ratios of 9.53 (95% CI 5.08–17.87) and 12.57 (7.17–22.04) respectively. Rate of gastrostomy tube placement increased from 2.82% to 3.32% with hazard ratio remaining elevated from 51.51 (13.45–197.33) to 35.2 (7.81–158.72) over the same time period. The rate of any dysphagia-related diagnosis or procedure increased from 14.9% to 26% with hazard ratio remaining elevated from 3.32 (2.50–4.42) to 2.12 (1.63–2.75). Treatment with radiation therapy and age over 65 were associated with increased hazard ratio for dysphagia-related diagnoses.

CONCLUSION: Our data supports our hypothesis that new dysphagia-related diagnoses continue to occur at clinically meaningful levels in long-term head and neck cancer survivors beyond 5 years after diagnosis.

Keywords

survivorship; late effects; head and neck cancer; squamous cell carcinoma; dysphagia

Introduction:

Head and neck cancer (HNC) is the 9th leading cause of new cancer diagnoses among men in the United States, with a predicted 35,700 new oral cavity and pharyngeal cancers as well as 10,570 laryngeal cancers in the year 2017.¹ Simultaneously, survival rates in head and neck cancers have improved considerably, with the relative 5 year survival for head and neck cancers increasing from 52.7% between 1982 and 1986 to 65.9% between 2002 and 2006.² These factors have combined to create an increasing population of survivors with long-term sequelae of HNC and its treatment.³

Of these sequelae, dysphagia is one of the most important issues cited by HNC survivors.^{4,5} In one representative study, patients rated swallowing their second most important issue behind the related issue of xerostomia.⁶

The high frequency of dysphagia within the first two years after diagnosis and treatment of HNC has been well established.^{7–15} However, few studies have examined swallowing outcomes more than five years after treatment. One of the few studies evaluating late-onset dysphagia in HNC survivors used a combination of quality of life assessments and video fluoroscopy, finding that 28.6% of patients reported moderate/severe choking five years after completing therapy and 47% of patients demonstrated aspiration on fluoroscopy a median of 67 months after completing treatment.¹⁶ This study was limited to patients who received primary radiation therapy as treatment, had not received surgery prior to radiation, and who had not received any chemotherapy, therefore provides information about only a small subset of HNC survivors.

Most available data detailing the prevalence of late-onset dysphagia are from single institution retrospective case series.¹⁰ Investigating dysphagia in large administrative datasets such as SEER-Medicare are hampered by underreporting of the specific diagnostic code for dysphagia.¹⁷ A few studies have established the utility of using related diagnoses as markers for dysphagia. Bhayani and colleagues undertook a study of gastrostomy tube (g-tube) placement in patients with HNC and found that of 474 patients, 8.9% continued to be

g-tube dependent at 12 months and 3.9% at 24 months after radiation therapy.¹⁸ Similarly, Xu and colleagues used the SEER database to investigate the dysphagia-related diagnosis of aspiration pneumonia in patients with HNC. Of 3513 patients, 801 developed aspiration pneumonia at a median of 5 months after the start of radiation. They found a 15.8% cumulative incidence at one year and 23.8% cumulative incidence at 5-years.¹⁹ However, as g-tube placement and aspiration pneumonia occur in a minority of patients with dysphagia, this data likely significantly underestimates the true rate of dysphagia in HNC survivors. In addition, given the limitation of SEER-Medicare data in that it is restricted to patients over the age of 65, the true prevalence of dysphagia related diagnoses are unknown. This knowledge gap is particularly important given the increasingly younger age of head and neck cancer survivors related to an expanding population of HPV-associated oropharyngeal cancer survivors.

Using a novel population-based cohort of HNC survivors with long-term follow-up, we investigate dysphagia and related diagnoses occurring in a delayed fashion after HNC treatment. The primary objective of the study was to determine the prevalence of new-onset dysphagia and related diagnoses occurring five years after treatment, as this is an area with a particular paucity of existing data. Our secondary objectives are to identify changes in rates of dysphagia-related diagnoses over varying time periods from diagnosis and to identify factors predictive of late-onset dysphagia.

Methods

Institutional review board approval was obtained for this study from the University of Utah.

Cohort development:

The Utah Population Database (UPDB) was used to establish a cohort of patients with HNC. This database links the Utah Cancer Registry, electronic medical records from the two largest hospital systems in Utah, statewide healthcare data, voter registration records, family history records, as well as birth and death certificates. This includes ambulatory surgery and inpatient billing data from the entire state of Utah from 1997–2012 as well as electronic medical records from University of Utah Healthcare (UHC) (1994–2015) and Intermountain Healthcare (IHC) (1994–2015), which together cover approximately 90% of Utah's population.

Cases with a diagnosis of malignancy of the oral cavity, pharynx, and larynx between 1992 and 2012 who were ≥18 years of age and were Utah residents at the time of diagnosis were identified giving 3,183 cases. 2012 was used as an end date to ensure at least 3 years of follow up. Cases with in-situ or missing stage information (n=285), a lack of at least three years follow up time (n=83), prior non-head and neck malignancy diagnoses (n=451), and duplicate cases (n=11) were excluded. In order to ensure adequate information about health prior to cancer diagnosis, those with a cancer diagnosis before 1996 were also excluded (n=447) given a lack of consistent electronic medical records prior to this time. For each case, up to five cancer-free controls were matched based on birth year, gender, and state of birth. Those patients without adequate controls were excluded from analysis (n=5). This gave a total of 1,901 cases and 7,796 matched controls for analysis. The Charlson

comorbidity index (CCI) was used to quantify the prognostic comorbidity of the two groups.²⁰ Vital status, body mass index, age at the end of follow up, and follow up period were also compared for the two groups. For the survivor group staging, cancer histology, primary site, and treatment were determined.

Evaluating late effects:

ICD-9 and CPT codes representing dysphagia and related diagnoses based upon a review of the medical literature were evaluated. Codes representing similar disease states were grouped together for analysis. For instance, enteral infusion of concentrated nutritional substances (ICD-9 96.6), encounter for attention to gastrostomy (ICD-9 V55.1), and gastrostomy present (ICD-9 V44.1) were all grouped under the category “Gastrostomy care and use.”

For each identified code or group of codes, prevalence of new diagnosis at 0–2, 2–5 years and 5+ years after diagnosis were determined for each dysphagia related diagnosis for cases and controls. For calculations of prevalence of new diagnosis, patients who had received that diagnosis in a previous time period were excluded. Cumulative prevalence of each dysphagia related diagnosis at 5–20 years after diagnosis was also determined, first excluding then including patients with preexisting diagnosis prior to HNC. Similar calculations were made for our birth year, gender and birth state matched control cohort in order to compare the progression of dysphagia related diagnosis rates in a group without HNC diagnosis over time. Cox Regression models were used to calculate hazard ratio based on time to event data as outcome variables over each time period, adjusted for BMI, CCI and race. These hazard ratios are also calculated in comparison to our matched cohort in order to control for changes in dysphagia related diagnosis not related to HNC. In order to determine characteristics associated with increased risk, we also used the Cox regression model to calculate hazard ratio and 95% confidence interval for gastrostomy tube placement and any dysphagia related diagnosis for different subgroups. Specifically, risk associated with treatment regimen, race, gender, age at diagnosis (under 65 versus 65 or over), overall stage at diagnosis, body mass index (BMI) (under 18, 18–24.9, 25–29.9 or more than 30 kg/m²), baseline CCI (0 versus 1 or more), cancer site, and rural versus urban setting were calculated.

Power analysis:

Sample sizes needed for power=0.80 and alpha=0.05 depend on the incidence of the late effect. For instance, with 1,901 cases included, for an effect with 10% incidence we are adequately powered to detect a relative risk of 1.3, whereas for an effect with only 1% incidence we are powered to detect a relative risk of 3.

Results:

Our cohort included 1901 HNC survivors and 7796 controls. Demographics of the cohort and control groups can be found in Table 1. As noted above, the two groups were matched based on birth year and gender. The majority of both groups were born between 1930 and 1960, with the largest portion, 27.0% of cases and 27.3% of controls, born between 1940

and 1949 ($p = 0.1949$). The majority of both groups were male, 73.7% of cases and 73.3 % of controls ($p=0.7549$). A small minority of both groups were non-white, however a significantly larger proportion of the controls, 8.2%, were non-white compared to cases, 2.9% ($p < 0.0001$). A greater percentage of the control group were living at the end of follow up, 83.3%, as compared to the patients with HNC, of whom only 46% were living at the end of follow up ($p < 0.0001$). Baseline BMI of the control group was significantly higher than baseline BMI of the HNC survivor group with 64.3% of controls being overweight or obese while only 56.1% of the case group was overweight or obese ($p < 0.0001$). The control group was noted to have a significantly higher comorbidity index compared to the survivor group ($p < 0.0001$) at baseline. Lastly, the follow up period for controls was significantly longer than that for survivors, with 70.2% of the control group being followed for more than 5 years while only 46.6% of cases were followed for more than 5 years ($p < 0.0001$).

Details regarding cancer characteristics for our HNC survivors are found in Table 2. Among HNC survivors, the majority (57.4%) were diagnosed between 50 and 69 years of age. At diagnosis, 23.4% of patients were stage I, 13.8% stage II, 14.0% stage III, 35.6% stage IV and 13.3% had stage information missing. The vast majority of patients, 90.2%, were diagnosed with squamous histology. The most common primary site was the oropharynx (33.3%) followed closely by oral cavity (29.77%) and larynx (24.46%). The largest portion of patients (33.67%) were treated with surgery alone followed by surgery and radiation (20.88%) and radiation and chemotherapy (11.2%).

Our results demonstrated persistently elevated prevalence of new diagnosis at 0–2, 2–5 and 5+ years after HNC compared to controls for all dysphagia-related diagnoses examined as detailed in Table 3. For these calculations, any patient who had received a given diagnosis in an earlier time period was excluded from later time periods. All queried diagnoses also demonstrated increased hazard ratio for cases compared to controls across all time periods. Prevalence of new dysphagia related diagnoses or procedures remained elevated over time in HNC survivors from 15.42% to 27.55% at 2–5 and 5 or more years respectively. Hazard ratio for survivors compared to controls for receiving any dysphagia diagnosis also remained elevated at 3.21 (95% CI 2.42–4.26) from 2–5 years and 2.03 (1.57–2.63) at 5 years or more. New aspiration pneumonia prevalence remained elevated in HNC survivors from 3.13% to 6.75% from 2–5 to 5 or more years after diagnosis. In addition, hazard ratio compared to controls for aspiration pneumonia remained elevated at 9.53 (5.08–17.87) from 2–5 years to 12.57 (7.17–22.04) at 5 or more years. Prevalence of gastrostomy tube placement procedural codes remained elevated among HNC survivors from 2.82% to 3.32% from 2–5 to 5 or more years. The risk of gastrostomy tube placement remained elevated compared to controls with a HR of 51.51 (13.45–197.33) between 2–5 years and 35.22 (7.81–158.72) at 5 or more years from diagnosis.

We also examined cumulative prevalence of dysphagia related diagnoses in patients between 5 and 20 years out from treatment including those who initially received a dysphagia related diagnosis in earlier time periods. Because previous studies have suggested dysphagia prior to HNC diagnosis is a risk factor for dysphagia after HNC diagnosis, we calculated this prevalence first including then excluding patients who had the dysphagia diagnosis prior to HNC diagnosis.^{12,16} We found 67.2% of all HNC survivors developed a dysphagia related

diagnosis at some point after HNC diagnosis while only 64.15% of HNC survivors without preexisting dysphagia before HNC developed a dysphagia related diagnosis after HNC ($p=0.0518$). Similarly, 14.57% of all HNC survivors developed aspiration pneumonia while 13.83% of those without preexisting diagnosis developed it after HNC ($p=0.3814$). Lastly 23.88% of all HNC survivors had a gastrostomy procedure performed at some point, while 23.46% of those without gastrostomy procedure before cancer diagnosis had this procedure at some point after cancer ($p=0.4673$). Cumulative prevalence of all diagnoses including diagnosis before HNC diagnosis can be found in Table 3.

Lastly, we investigated risk factors for dysphagia related diagnoses by determining odds ratio associated with various risk factors as noted in Figure 1. HNC survivors treated with radiation therapy had a significantly higher risk of gastrostomy tube placement more than 5 years after treatment as compared to those treated with surgery alone. Both the use of radiation therapy alone and the combination of radiation and surgery demonstrated an elevated risk for gastrostomy tube placement over surgery alone (HR = 5.77 (95% CI = 1.60–20.57) and 3.25 (95% CI = 1.21 – 8.71) respectively). Patients treated with radiation therapy also had a significantly higher risk of having any new dysphagia related diagnosis or procedure, with an elevated hazard ratio of 11.91 (2.23–63.70) for patients treated with radiation alone and 5.73 (1.50–21.96) for those treated with surgery and radiation. Age greater than 65 was associated with increased risk of being diagnosed with any dysphagia related diagnosis or procedure more than 5 years after treatment, HR 2.54 (1.75 – 3.69). Increasing overall stage at diagnosis was associated with increased risk of dysphagia related diagnosis in the initial 2 years following cancer diagnosis, but this effect did not persist over time. Baseline BMI less than 18 kg/m² was also associated with increased risk of dysphagia related diagnosis more than 5 years after treatment with hazard ratio of 5.66 (1.69–18.98). Patients with primary cancer site in the hypopharynx and larynx had increased risk of dysphagia related diagnosis after 5 years with hazard ratios of 3.59 (1.09–11.85) and 2.06 (1.33–3.19) respectively.

Discussion:

To our knowledge, this is the first study to look at effects of HNC and its treatment on the development of dysphagia-related diagnoses in a large population-based cohort of both young and elderly HNC survivors. This study is unique in that it uses a population-based database with complete data for patients of all ages, as opposed to SEER Medicare data, which is limited for patients under age 65. This is particularly important given the changing demographics of HNC, with an increasing portion of diagnoses occurring in younger patients.²

Our results demonstrated increased risk of gastrostomy with any radiation therapy. This may be confounded by increased likelihood of receiving radiation in difficult to resect tumors and increased likelihood of receiving combined therapies in patients with more advanced disease. However, treatment with radiation alone, which is generally reserved for earlier stage cancers, was associated with more risk than combined therapy, which is used for more advanced cancers. In addition, this is consistent with existing literature, which has identified both radiation alone and combined chemotherapy and radiation as risk factors for dysphagia.

^{21,22} It is not entirely clear why radiation therapy alone was associated with a higher risk than combined chemotherapy and radiation. It is possible that this difference reflects de-escalation of radiation dose in those patients who received combination therapy. However, our dataset does not include information on radiation dose received, therefore we cannot analyze this. We intend to further address this question in future work.

We noted strong correlation of dysphagia with both radiation therapy and combined chemoradiation. This is consistent with existing literature.^{11,12,21–24} Given this strong association, we would hypothesize there is likely an association between radiation toxicity and late-onset dysphagia. Hutcheson and coworkers have explored the phenomenon of late radiation-associated dysphagia, which often begins more than 5 years after HNC and is associated with additional lower cranial neuropathies.^{25,26}

We noted lower risk of dysphagia in younger patients and higher risk of dysphagia in older patients, which is consistent with previous literature.¹⁶ However, our cohort represents a more diverse age range than previous studies, particularly those based on Medicare data, making this finding more interesting. Further adding to the importance of these findings, in recent years the median age of diagnosis for HNC has declined significantly.³

Interestingly, we did not find overall stage to correlate with increased risk of dysphagia more than two years after treatment. Previous studies have correlated increased T stage with increased risk of long term dysphagia.^{23,24,27} We noted risk of dysphagia to increase location in the hypopharynx, which has been previously suggested.¹⁹

There is an ongoing question in our field as to whether prophylactic feeding tube placement may contribute to long-term dysphagia. Past studies have been mixed in their results, with some showing better long-term quality of life and shorter tube dependence without prophylactic gastrostomy tube placement and others refuting this finding.^{28–31} It is possible that prophylactic gastrostomy tube placement may be a complicating factor for some patients in our cohort. Unfortunately, we are unable to determine definitively from our data which gastrostomy tubes were placed prophylactically and which were placed reactively. Therefore, we are unable to control for this factor or to further contribute to the literature regarding this question.

Our study is limited in that it likely underestimates rates of dysphagia as providers frequently undercode for these diagnoses. One previous study examined all patients receiving videofluorographic swallowing study at a single tertiary care hospital over 6 months, comparing the swallow study reports to coding associated with that admission. They found that the dysphagia code 787.2 had a sensitivity of only 22.8% with specificity of 89.5%.¹⁷ Another study performed chart reviews to determine whether they contained documentation for coded hospitalization complications. They found that the aspiration pneumonia code had a specificity of 91%, with 50% of cases having objective clinical evidence and 37.5% having a physician note documenting the diagnosis, but did not investigate sensitivity.³² Furthermore, while we have a relatively large cohort, these more severe consequences occur in a very small proportion of patients, limiting statistical sensitivity as noted by our wide confidence intervals.

Conclusions:

Our data suggests that new dysphagia-related diagnoses continue to occur at clinically meaningful levels in long-term HNC survivors. This has relevance with regard to initial patient counseling and treatment decisions as well as long-term HNC survivorship care. Better tools to identify patients that could benefit from long-term dysphagia management are needed

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Figure 1.

Hazard ratio for any dysphagia related diagnosis associated with various risk factors at different time periods.

Table 1:**Cohort Characteristics**

	N=1901	N=7796	
	Cases (%)	Cancer-free (%)	p-value
Birth year			
1904–1919	78 (4.1)	310 (4.0)	0.1949
1920–1929	233 (12.3)	843 (10.8)	
1930–1939	427 (22.5)	1610 (20.7)	
1940–1949	514 (27.0)	2126 (27.3)	
1950–1959	450 (23.7)	1984 (25.5)	
1960–1969	142 (7.5)	655 (8.4)	
1970–1979	47 (2.5)	220 (2.8)	
1980–1989	10 (0.5)	48 (0.6)	
Gender			
Female	500 (26.3)	2078 (26.7)	0.7549
Male	1401 (73.7)	5718 (73.3)	
Race			
Non-White	56 (2.9)	638 (8.2)	<0.0001
White	1845 (97.1)	7158 (91.8)	
Vital status			
Alive	875 (46.0)	6490 (83.2)	<0.0001
Deceased	1026 (54.0)	1306 (16.8)	
Body mass index at baseline			
Less than 18kg/m2	21 (1.1)	32 (0.4)	<0.0001
18–24.9 kg/m2	814 (42.8)	2748 (35.2)	
25–29.9kg/m2	751 (39.5)	3352 (43)	
More than 30kg/m2	315 (16.6)	1664 (21.3)	
Charlson Comorbidity Index			
≥1	751 (39.5)	2288 (29.3)	<0.0001
0	1150 (60.5)	5508 (70.7)	
Mean	0.91	0.59	
Standard deviation	1.64	1.27	
Age at the end of follow			
27–59	520 (27.4)	1695 (21.8)	<0.0001
60–69	570 (30.0)	2362 (30.3)	
70–79	485 (25.5)	2034 (26.1)	
80–84	163 (8.6)	780 (10.0)	
85–99	163 (8.6)	925 (11.9)	
Follow up period			
0–2 Years	564 (29.7)	254 (3.3)	<0.0001
2–5 Years	452 (23.8)	2071 (26.6)	
5–10 Years	507 (26.7)	2699 (34.6)	

	N=1901	N=7796	
	Cases (%)	Cancer-free (%)	p-value
10–20 Years	378 (19.9)	2772 (35.6)	

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Table 2:**HNC Case Characteristics**

	N=1901
	Cases (%)
Age at diagnosis	
< 65	1156 (60.8)
>= 65	745 (39.2)
Diagnosis year	
1996–2000	470 (24.7)
2001–2005	540 (28.4)
2006–2010	608 (32.0)
2011–2012	283 (14.9)
Cancer stage at diagnosis	
I	444 (23.4)
II	262 (13.8)
III	266 (14.0)
IV	677 (35.6)
Missing	252 (13.3)
Histology	
Not squamous	186 (9.8)
Squamous	1715 (90.2)
Site	
Oral cavity (OC)	566 (29.8)
Oropharynx	633 (33.3)
Hypopharynx	89 (4.7)
Larynx	465 (24.5)
OC,oroph,hypoph NOS	148 (7.8)
Treatment	
Surgery only	640 (33.7)
Radiation only	168 (8.8)
Surgery+radiation	397 (20.9)
Radiation+chemo	310 (16.3)
Surgery+chemo+rad	213 (11.2)
Other	96 (5.1)
Missing	77 (4.1)

Table 3:

Prevalence and hazard ratio of dysphagia for HNC versus controls

Dysphagia Related Diagnosis or Procedure	ICD-9 and/or CPT codes	New diagnosis 0–2 Years			New diagnosis 2–5 Years			New diagnosis 5+ Years			Cumulative	
		Controls %	Cases %	Hazard Ratio (95% CI)	Controls %	Cases %	Hazard Ratio (95% CI)	Controls %	Cases %	Hazard Ratio (95% CI)	Controls %	Cases %
Any Dysphagia Related Diagnosis or Procedure	*	3.41	47.79	25.005 (20.53 – 30.46)	5.45	15.42	3.212 (2.42 – 4.26)	13.20	27.55	2.033 (1.57 – 2.63)	23.32	67.12
<i>Dysphagia</i>	787.2 **	1.14	29.59	33.43 (25.43 – 43.95)	2.25	9.86	7.68 (5.25 – 11.24)	4.73	14.63	7.31 (4.96 – 10.77)	9.58	43.98
<i>Feeding difficulty</i>	783.3	0.03	3.75	157.79 (32.77 – 759.87)	0.05	1.15		0.13	0.82	9.44 (1.92 – 46.46)	0.19	5.31
<i>Problems with swallowing and mastication</i>	V41.6	0.00	0.32		0.01	0.08		0.05	0.11		0.05	0.42
<i>Esophageal stricture</i>	530.3	0.72	4.70	7.23 (5.00 – 10.44)	1.01	3.55	5.19 (3.22 – 8.37)	1.64	4.28	5.34 (3.00 – 9.51)	5.18	11.36
<i>Esophageal spasm</i>	530.5	0.22	0.58	53.96 (35.13 – 82.90)	0.40	1.14	4 (1.85 – 8.66)	0.81	1.73	5.13 (2.25 – 2.25)	1.54	2.79
<i>Malnutrition</i>	263.0, 263.1, 263.8, 263.9	0.59	18.88	15.65 (10.42 – 23.51)	0.80	6.06	19.41 (10.85 – 34.73)	1.89	7.75	16.81 (9.04 – 31.27)	3.35	27.67
<i>Abnormal weight loss</i>	783.21	0.52	6.71	13.28 (9.76 – 18.06)	0.89	3.96	9.11 (5.27 – 15.76)	2.61	6.82	6.78 (4.20 – 10.92)	4.08	14.73
<i>Dehydration</i>	276.51	1.01	10.42	584.72 (134.75 – 2537.28)	1.47	3.67	4.86 (2.99 – 7.90)	5.64	9.75	4 (2.83 – 5.66)	7.30	18.94
<i>Aspiration pneumonia</i>	507	0.44	8.36		0.75	3.13	9.53 (5.08 – 17.87)	1.77	6.75	12.57 (7.17 – 22.04)	3.01	14.57
<i>Gastrostomy Care and Use</i>	96.6, V55.1, V44.1	0.06	14.90		0.11	2.58	170.57 (21.10 – 1378.83)	0.26	4.74	64.84 (14.34 – 293.10)	0.38	18.78
<i>Gastrostomy Procedure Performed</i>	43246, 43750, 43830, 43653, 43.11, 43.19	0.00	20.57		0.12	2.82	51.51 (13.45 – 197.33)	0.13	3.32	35.22 (7.81 – 158.72)	0.23	23.88
PEG	43246	0.00	10.44		0.09	1.57	28.42 (7.86 – 102.77)	0.13	2.50	29.49 (6.28 – 138.49)	0.19	12.68
Percutaneous gastrostomy	43750	0.00	5.63	39.98 (4.91 – 325.39)	0.00	0.63		0.00	0.24		0.00	6.21

Dysphagia Related Diagnosis or Procedure	ICD-9 and/or CPT codes	New diagnosis 0–2 Years			New diagnosis 2–5 Years			New diagnosis 5+ Years			Cumulative	
		Controls %	Cases %	Hazard Ratio (95% CI)	Controls %	Cases %	Hazard Ratio (95% CI)	Controls %	Cases %	Hazard Ratio (95% CI)	Controls %	Cases %
Open gastrostomy	43830	0.01	0.53	37.99 (19.32 – 74.70)	0.01	0.23	21.02 (0.45 – 987.43)	0.00	0.23		0.03	0.84
Laparoscopic gastrostomy	43653	0.00	0.47		0.00	0.15		0.00	0.11		0.00	0.63
<i>Swallow Study Performed</i>	92612, 92616, 70370, 70371, 74230, 92610, 92611	0.42	9.31	37.496 (22.923 – 61.331)	0.88	3.74	4.527 (2.79 – 7.35)	3.75	12.00	4.879 (3.41 – 6.98)	4.16	17.41
FEEST	92612, 92616	0.03	0.58	3.44 (1.44 – 8.22)	0.04	0.23	2.48 (0.13 – 48.71)	0.16	1.03	19.35 (2.50 – 149.67)	0.18	1.32
Modified Barium Swallow Study (MBSS)	70370, 70371, 74230	0.19	5.22	34.5 (20.45 – 58.23)	0.28	2.54	10.85 (5.28 – 22.29)	1.15	6.94	17.92 (9.19 – 34.94)	1.35	10.31
ESF	92610	0.32	6.60	38.58 (21.54 – 69.11)	0.79	3.20	11.14 (5.51 – 22.53)	3.38	9.06	10.35 (6.40 – 16.74)	3.66	13.15
MF	92611	0.17	4.53	36.32 (18.27 – 72.20)	0.28	2.05	9.53 (4.38 – 20.75)	1.04	6.60	19.73 (9.66 – 40.32)	1.24	9.15
<i>Treatment of swallowing dysfunction and/or oral function for feeding</i>	92526	0.23	4.80	30.48 (16.19 – 57.37)	0.47	1.96	14.66 (5.61 – 38.31)	1.74	6.25	15.19 (7.87 – 29.30)	2.00	9.15

* This category includes all of the other ICD-9 and CPT codes

** This category includes 787.2 and subcodes 787.21, 787.22, 787.23, 787.24, 787.29

CI = confidence interval, PEG = percutaneous endoscopic gastrostomy, FEEST = Flexible Endoscopic Evaluation of Swallowing with Sensory Testing ESF = Evaluation of oral and pharyngeal swallowing function, MF = Motion fluoroscopic evaluation of swallowing function by cine or video recording