This article is downloaded from 

http://researchoutput.csu.edu.au

It is the paper published as:

**Authors:** Howle, A.A., Nott, M., and Baguley, I.J.
**Title:** Aspiration pneumonia following severe traumatic brain injury; prevalence and risk factors for long-term mortality
**Journal:** Brain Impairment
**ISSN:** 1443-9646
**Year:** 2011
**Volume:** 12
**Issue:** 3
**Pages:** 179-186

**Abstract:**
Dysphagia and aspiration pneumonia are prevalent but infrequently studied complications following severe traumatic brain injury (TBI). Aspiration pneumonia is responsible for a significant number of long-term deaths in this population, however, the number of deaths attributed to aspiration pneumonia may be inaccurate. This multi-centre inception cohort (n = 2545) study of consecutive discharges from three metropolitan inpatient brain injury rehabilitation units aimed to 1) evaluate the prevalence of aspiration pneumonia, percutaneous endoscopic gastrostomy (PEG) insertion and dysphagia following TBI; 2) identify the number of deaths ascribed to aspiration pneumonia, and 3) characterise associated risk factors for long-term aspiration pneumonia related deaths compared to all other causes of death. In-hospital PEG insertion occurred in 18.4% of the sample, 2/3 of whom remained dysphagic at discharge. In-hospital aspiration pneumonia was recorded in 3.6% of the sample. Post-discharge, people with TBI were 79 times more likely to die from aspiration pneumonia than the general population. Risks were higher for subjects discharged to a nursing home, with severe ongoing functional disability, dysphagia at discharge, in those who had experienced in-hospital aspiration pneumonia or required PEG insertion. Early identification and risk management of dysphagia and aspiration pneumonia in TBI nursing home populations may maximise these individuals’ quality and length of life.

http://dx.doi.org/10.1375/brim.12.3.179
Aspiration pneumonia following severe traumatic brain injury; prevalence and risk factors for long-term mortality.

Alison A Howle, Melissa T Nott & Ian J Baguley

Brain Injury Rehabilitation Service, Westmead Hospital, Sydney, Australia

Suggested running head: Aspiration pneumonia and severe TBI

Corresponding author:
A/Prof Ian Baguley
Brain Injury Rehabilitation Service
PO Box 533
Wentworthville NSW 2145
ianb@biru.wsahs.nsw.gov.au
phone: 02 9845 7941
fax: 02 9635 8892
Abstract

Dysphagia and aspiration pneumonia are prevalent but infrequently studied complications following severe traumatic brain injury (TBI). Aspiration pneumonia is responsible for a significant number of long-term deaths in this population, however, the number of deaths attributed to aspiration pneumonia may be inaccurate. This multi-centre inception cohort (n = 2545) study of consecutive discharges from three metropolitan inpatient brain injury rehabilitation units aimed to 1) evaluate the prevalence of aspiration pneumonia, percutaneous endoscopic gastrostomy (PEG) insertion and dysphagia following TBI; 2) identify the number of deaths ascribed to aspiration pneumonia, and 3) characterise associated risk factors for long-term aspiration pneumonia related deaths compared to all other causes of death.

In-hospital PEG insertion occurred in 18.4% of the sample, 2/3 of whom remained dysphagic at discharge. In-hospital aspiration pneumonia was recorded in 3.6% of the sample. Post-discharge, people with TBI were 79 times more likely to die from aspiration pneumonia than the general population. Risks were higher for subjects discharged to a nursing home, with severe ongoing functional disability, dysphagia at discharge, in those who had experienced in-hospital aspiration pneumonia or required PEG insertion. Early identification and risk management of dysphagia and aspiration pneumonia in TBI nursing home populations may maximise these individuals’ quality and length of life.
**Key words:** Traumatic brain injury, Aspiration pneumonia, Dysphagia, Mortality, Cause of death coding, Rehabilitation
Introduction

Dysphagia and aspiration pneumonia are recognised as significant clinical problems for survivors of traumatic brain injury (TBI). Poorly managed dysphagia has been causally linked with an increased risk of aspiration pneumonia (Altman, Yu, & Schaefer, 2010; Hansen, Larsen, & Engberg, 2008; Langmore, et al., 1998; Quagliarello, et al., 2005), increased functional dependency (Smithard, et al., 1996; Smithard, Smeeton, & Wolfe, 2007), malnutrition (Garcia-Peris, et al., 2007), longer hospital admissions (Altman, et al., 2010; Smithard, et al., 1996), reduced quality of life (Garcia-Peris, et al., 2007), modified diets (Martino, Beaton, & Diamant, 2009) and/or enteral feeding, and psychosocial issues (Ekberg, Hamdy, Woisard, Wuttge-Hannig, & Ortega, 2002; Martino, et al., 2009). Despite this, there is limited information regarding the prevalence and clinical impact of the problem in adults with TBI. Furthermore, the true contribution of dysphagia and aspiration pneumonia to mortality following TBI is not evident from the literature.

The lack of literature available regarding the impact of aspiration pneumonia may be due to differences in disease diagnosis and coding. Aspiration pneumonia is caused by the inhalation of food, fluid or oropharyngeal secretions and the subsequent bacterial colonisation of the lungs (Marik, 2001). Aspiration pneumonia is distinct from aspiration pneumonitis, in which lung damage results from the inhalation of acidic gastric contents. However, in the clinical context, it can be difficult to differentially diagnose between the two disease processes, commonly resulting in pneumonitis being presumptively treated as aspiration pneumonia (Finegold, 1991). This common clinical scenario is mirrored in the ICD-10 disease classification system (WHO, 2007), where
Aspiration pneumonia is classed as ‘pneumonitis’ (Chapter X, code J69), whereas ‘inhalation of gastric contents’ is classed as such and not as ‘pneumonitis’ (Chapter XX, code W78). Aspiration pneumonia is also subsumed under general pneumonia codes in TBI mortality literature (Baguley, Nott, & Slewa-Younan, 2008; Baguley, Slewa-Younan, Lazarus, & Green, 2000; Harrison-Felix, Whiteneck, DeVivo, Hammond, & Jha, 2006; McMillan & Teasdale, 2007; Pentland, Hutton, & Jones, 2005; Shavelle, Strauss, Whyte, Day, & Yu, 2001), either due to a lack of recognition of the different disease aetiologies at diagnosis or resulting from the use of a more global style of disease classification.

An estimated 37.5% to 62.5% of dysphagic TBI survivors have discrete aspiration events (Field & Weiss, 1989; Lazarus & Logemann, 1987; Mackay, Morgan, & Bernstein, 1999a, 1999b). The variable prevalence in these studies may be linked to differences in cognitive outcomes and levels of disability in each sample (Terre & Mearin, 2009) and methodological issues. Further, very few studies have reported the prevalence of aspiration pneumonia resulting from these dysphagic events in TBI populations. One study reported an incidence of 27% for ‘pneumonia’ at discharge from intensive care compared to 12% during rehabilitation (Hansen, Larsen, et al., 2008). The risk of developing pneumonia was reportedly greater in subjects with lower Glasgow Coma Scale (GCS) scores one day post-withdrawal of sedation, with a tracheostomy in situ or being enterally fed. Whilst these were cases of aspiration pneumonia, the authors were unable to use the term ‘aspiration pneumonia’ due to diagnostic limitations.
In addition to contributing to in-hospital morbidity, aspiration pneumonia is a recognised cause of death in people surviving six or more months post-TBI (Harrison-Felix, et al., 2009; Ventura, et al., 2010). However, several studies fail to distinguish between deaths due to aspiration pneumonia compared to ‘pneumonia’ or the more general ‘diseases of the respiratory system’ (Baguley, et al., 2008; Baguley, et al., 2000; Harrison-Felix, et al., 2006; McMillan & Teasdale, 2007; Pentland, et al., 2005; Shavelle, et al., 2001). The two key studies that identified aspiration pneumonia as a significant cause of death found cause-specific standardised mortality ratios (SMRs) for deaths due to aspiration pneumonia to be 3.4 (Ventura, et al., 2010) and 48.6 (Harrison-Felix, et al., 2009), meaning that people with TBI were up to 48 times more likely to die from aspiration pneumonia than a population-based age and sex matched sample.

The clinical association between long-term deaths due to aspiration pneumonia following TBI and risk factors such as discharge destination, post-injury dysphagia, percutaneous endoscopic gastrostomy (PEG) insertion and functional dependency has not been investigated. TBI survivors who are discharged to nursing homes typically have significant disability and require a high level of functional support (Tooth, et al., 2001): factors which are known to be associated with dysphagia and aspiration pneumonia (Langmore, Skarupski, Park, & Fries, 2002). This particular population of TBI survivors is therefore at a high risk of developing aspiration pneumonia.

On this background, the current study aimed to 1) evaluate the prevalence of aspiration pneumonia, PEG insertion and dysphagia following TBI in a multicentre inception cohort; 2) identify the number of deaths ascribed to aspiration pneumonia from official
statistics and evaluate the accuracy of this information using single and multiple cause of death analyses, and 3) characterise long-term TBI deaths associated with aspiration pneumonia compared to all other causes of death and to investigate the associated risk factors.

Method

Sample
Following ethics approval, an inception cohort of 2545 consecutive discharges were identified from three inpatient brain injury rehabilitation units in NSW commencing from 1st January 1990. Subjects were aged 16-70 years at time of injury, received rehabilitation for a primary severe traumatic brain injury and were discharged alive from the rehabilitation service prior to the 1st October 2007. For full details refer to Baguley et al (under review).

Data Collection
Demographic data, pre-injury medical history, clinical variables and service variables were collected for all subjects in the sample from clinical databases, discharge reports or medical records. Aspiration-related variables (occurrence of in-hospital aspiration pneumonia and in-hospital PEG insertion) were determined from each subject’s clinical record. The presence of dysphagia at discharge was identified from medical and speech pathology discharge reports where subjects required a modified diet (including enteral feeding) and/or modified fluids at discharge. Date, cause and place of residence at time of death were sought from two national data registries, the National Death Index and the National Coroners Information System.
Data analysis

The total number of subjects in the sample with in-hospital aspiration pneumonia, in-hospital PEG insertion and dysphagia at discharge was calculated. Availability of clinical data for each of these variables was 86%, 67% and 69% respectively. Subjects’ survival status was assessed over a minimum two year period via an anchor point of 1st October 2009. Subjects who were alive at the anchor point were classified as thus. Deceased subjects where the ICD-10 cause of death was coded to the original TBI were re-categorised based on data from death certificates into subjects who died due to aspiration pneumonia and subjects who died from all other causes. Subjects with a single cause of death code of ICD-10 code J69.0 (pneumonitis/aspiration pneumonia due to food and vomit) were classed as a death due to aspiration pneumonia. Additional cases of pre-terminal aspiration pneumonia were identified where multiple causes of death were reported on death certificates. Acute asphyxic events leading to death (ICD-10 codes W78, W79) were not included in this aspiration pneumonia classification and were grouped with deaths from all other causes.

Demographic and clinical differences between these three groups (alive; death due to aspiration pneumonia; death due to all other causes) were calculated. Age and sex differences between groups were determined by analysis of variance (ANOVA) and chi-square tests. Differences in mortality-related variables, including survival time, were compared between the two deceased groups using ANOVA. Differences in outcome
were compared using the Mantel-Cox log-rank test of homogeneity to account for exposure years, that is, time from discharge to anchor date in surviving subjects or from discharge to date of death in all deceased subjects. All group differences were considered significant when \( p \leq 0.05 \).

The SMR for deaths due to aspiration pneumonia was calculated by comparing the observed number of deaths to the expected number of deaths due to aspiration pneumonia in an age and sex matched Australian reference population averaged over the years 1997 to 2008. An SMR greater than one indicates an increased risk of actual mortality compared to the expected mortality rate of an age and sex matched population.

The risk factors associated with dying from aspiration pneumonia were assessed via Cox proportional hazards regression analyses. In this analysis, subjects who died from aspiration pneumonia were compared to subjects who died from all other causes, therefore the resultant hazard ratio represents the additional risk of dying from aspiration pneumonia over all other causes for each risk factor. Hazard ratios with 95% confidence intervals were calculated for all variables.

**Results**

Demographic data, pre-injury medical history, clinical variables and service variables for the sample have been published previously (Baguley, et al., under review). Overall, the records of 2545 subjects, (81% male, mean age of 35 years) were reviewed. Injury severity was available for 2234 subjects, with 2135 (96%) sustaining severe injuries and 99 (4%) mild injuries.
In-hospital aspiration pneumonia was recorded in 79 of 2199 subjects (3.6%) of the sample. PEG insertion during hospitalisation occurred in 311 of 1692 subjects (18.4%). At discharge, 204 subjects (11.6%) continued to experience dysphagia, of whom 93 required enteral feeding, (90 via PEG and 3 via nasogastric tube) while 111 were on a modified oral diet or fluids.

Of the 258 deaths recorded at the anchor date, 19 (7.4%) were ascribed an ICD-10 single cause of death code consistent with aspiration pneumonia. The predicted number of deaths due to aspiration pneumonia in an age and sex matched population was 0.240, yielding a cause-specific SMR of 79.2 (95% CI: 46.8 – 116.2). Analysis of death certificates containing multiple cause of death data identified an additional seven cases where aspiration pneumonia was a direct factor in the chain of events leading to death. Further analyses were undertaken using these 26 aspiration pneumonia-related deaths.

Subjects who were alive at the anchor point were significantly younger than subjects who died from aspiration pneumonia or from all other causes (alive = 34±14 years; aspiration pneumonia deaths = 46±13 years; all other death 45±15 years; F = 78.01, p <.001). Females were significantly more likely to be alive at the anchor point (95% of females alive versus 87% of males; $X^2 = 17.8$, p <.001). The proportion of males and females in the death due to aspiration pneumonia group and deaths due to all other causes group were equivalent.
Clinical outcomes were compared between subjects who died from aspiration pneumonia, subjects who died from all other causes, and subjects who were alive at the anchor point (refer to Table 1).

**INSERT TABLE 1 HERE**

A significantly greater proportion of subjects who died due to aspiration pneumonia were diagnosed with in-hospital aspiration pneumonia (19%), had an in-hospital PEG insertion (58%) and presented with dysphagia at discharge (58%) compared to those who were alive or who died due to all other causes. The aspiration pneumonia group also had a significantly larger proportion of subjects with longer rehabilitation length of stay, lower FIM discharge scores and who were discharged to nursing homes. Further, time to death from discharge did not differ significantly between the two deceased groups (F = 0.333, p = 0.564). Subjects who died from aspiration pneumonia survived for a mean of 6.0 years (SD = 4.6), and subjects who died from all other causes survived for an average of 5.6 years (SD = 4.1) following rehabilitation discharge.

All variables from Table 1 underwent Cox regression analysis to determine what factors increased the risk of death due to aspiration pneumonia. Results are displayed in Table 2. Factors directly related to swallowing function, including in-hospital aspiration pneumonia, in-hospital PEG insertion and dysphagia at discharge from rehabilitation, led to an eight to 14 fold increase in risk of death due to aspiration pneumonia. In addition, general indicators of greater functional disability such as length of rehabilitation stay, lower FIM score and nursing home discharge elevated risk of death
due to aspiration pneumonia by two to 46 times. The shared variance between these risk factors is acknowledged to be substantial.

**INSERT TABLE 2 HERE**

**Discussion**

Aspiration pneumonia is a recognised complication and cause of death following TBI. This study sought to identify the prevalence of known risk factors associated with aspiration pneumonia in an inception cohort of 2545 TBI subjects who survived to discharge from rehabilitation, analyse the accuracy of cause of death reporting for aspiration pneumonia and describe the differences between subjects who died due of aspiration pneumonia and those who died from all other causes.

The prevalence of in-hospital PEG insertion (18%) and dysphagia at discharge (12%) were comparable to previous TBI studies (Field & Weiss, 1989; Halper, Cherney, Cichowski, & Zhang, 1999; Hansen, Engberg, & Larsen, 2008; Mackay, et al., 1999b; Morgan, Ward, Murdoch, Kennedy, & Murison, 2003; Winstein, 1983), confirming dysphagia as a significant co-morbidity following severe TBI. However, only 4% of all subjects developed in-hospital aspiration pneumonia, less than the 12% estimate reported previously (Hansen, Larsen, et al., 2008). While methodological differences may explain the variability in these results, it may also represent the inherent difficulty in differentially diagnosing aspiration pneumonia from aspiration pneumonitis and pneumonia (Finegold, 1991; Marik, 2001). Such differences in disease diagnosis and coding could lead to incorrect reporting of the prevalence and incidence of aspiration pneumonia.
While the occurrence of in-hospital aspiration pneumonia was lower than previous studies, the cause-specific SMR for long term mortality due to aspiration pneumonitis/pneumonia was higher, being 79.2 compared to 48.6 (Harrison-Felix, et al., 2009) and 3.4 (Ventura, et al., 2010) in previous studies. The overlap in confidence intervals for the current and Harrison-Felix’s study suggests that both study samples were drawn from similar populations, and that the true SMR lies somewhere in the range around these higher values. In contrast, it is likely that the sample in Ventura’s (2010) study was drawn from a different population, representing a greater proportion of people with mild/moderate TBI. This would reduce the SMR as it is known that greater injury severity and functional disability contribute to increased long term mortality (Baguley, et al., 2008).

Despite the high cause-specific SMR found in the current study, there are reasons to believe that this value under-ascribes deaths associated with aspiration. Previous TBI long-term mortality studies have utilised single cause of death data for their study populations (Baguley, et al., 2008; Baguley, et al., 2000; Harrison-Felix, et al., 2006; Harrison-Felix, et al., 2009; McMillan & Teasdale, 2007; Shavelle, et al., 2001; Ventura, et al., 2010). Utilising a multiple cause of death analysis for each subject in this study, an additional seven deaths were identified as having aspiration pneumonia in the direct chain of events that culminated the subject’s death. This represents a relative increase for aspiration pneumonia-related mortality of 37%, suggesting that single cause of death data significantly under-reports the true contribution of aspiration pneumonia to long-term TBI mortality.
Subjects who died from aspiration pneumonia had greater overall functional disability at rehabilitation discharge compared to those who died from all other causes and to those who were alive. This was evidenced by significant differences between the three groups regarding length of rehabilitation stay, post-discharge nursing home placement, functional disability and dysphagia prevalence. These significant differences are in keeping with those previously identified as being associated with aspiration pneumonia and dysphagia (Altman, et al., 2010; Garcia-Peris, et al., 2007; Martino, et al., 2009; Smithard, et al., 1996; Smithard, et al., 2007).

The greatest risk factors for death due to aspiration pneumonia were being discharged to a nursing home, having maximal functional dependency or ongoing dysphagia at rehabilitation discharge, in-hospital aspiration pneumonia or PEG insertion and increased length of rehabilitation stay. These results parallel studies investigating predictors of aspiration pneumonia in general nursing home and aged populations (Langmore, et al., 2002; Langmore, et al., 1998). People in nursing homes with markers of dysphagia and high functional dependency are known to be at an increased risk of developing aspiration pneumonia (Langmore, et al., 2002). The current study demonstrates that this relationship also exists in young people with TBI in nursing homes.

Dysphagia can be managed using compensatory and rehabilitative treatment options (Logemann, 1998; Logemann, et al., 2008) to reduce the likelihood of associated morbidity and mortality (Doggett, et al., 2001). Ensuring good oral hygiene to reduce
the colonisation of oropharyngeal flora particularly in non-oral patients (Langmore, et al., 1998; Quagliarello, et al., 2005) and appropriate management to limit gastro-oesophageal reflux can also reduce the risk of aspiration pneumonia or pneumonitis developing. However, there is limited data on the success of dysphagia treatment for people with TBI (Martens, Cameron, & Simonsen, 1990; Schurr, et al., 1999). Despite this, early identification of people who are at-risk of dysphagia in this population appears essential to maximising life expectancy. Also, ensuring continuum of care between healthcare facilities is key to the effective management of dysphagia and aspiration pneumonia.

However, in nursing home populations, where patients are particularly disabled, unwell and have a diminished quality of life, successful prevention and treatment of aspiration pneumonia may not be possible, with aspiration pneumonia becoming a recurring issue. In such circumstances, it is not inappropriate that physicians consider end of life issues, and in some cases may, in consultation with family/carers, withhold or withdraw artificial nutrition or hydration and antibiotic therapy (Baguley, et al., 2008; Groenewoud, et al., 2000; van der Steen, Ooms, Ader, Ribbe, & van der Wal, 2002). However, such end of life decisions, whether appropriate or otherwise, cannot be identified from death certificates.

Strengths of this study include the multi-site, inception cohort used for data analysis, the extended sampling period and greater capture of mortality via the use of national death registries. However, the retrospective nature of the data collection and minor differences in recording practices across the three sites resulted in lower completion rates for some
variables. Despite this, variables in the study had completion rates between 64 and 100%. As discussed in the text, diagnostic issues surrounding aspiration pneumonia may have resulted in an under-reporting of the condition in medical records and death certificates. Finally, the features used for a diagnosis of dysphagia were relatively crude, involving examination of medical and speech pathology discharge reports for the reported presence of a PEG or modified diet/fluids. This process may not have identified milder cases of dysphagia requiring alternative clinical management.

**Conclusion:**

This study confirms that aspiration pneumonia, PEG insertion and dysphagia are significant co-morbidities following severe TBI. Following discharge from inpatient rehabilitation, people with TBI were 79 times more likely to die from aspiration pneumonia, particularly if they were discharged to a nursing home, experienced ongoing severe functional disability, had dysphagia at discharge, in-hospital aspiration pneumonia or required in-hospital PEG insertion. This value probably represents an under-estimate of the true impact of aspiration pneumonitis/pneumonia on late mortality post-TBI. Early identification and risk management of dysphagia and aspiration pneumonia in TBI nursing home populations may maximise these individuals’ quality and length of life.
Acknowledgements:

The authors gratefully acknowledge the contributions of Dr Karen Byth, Louise Brown and the members of the Multi-centre Mortality Study group. The authors thank the Lifetime Care and Support Authority of New South Wales for their financial support (research grants 08157 and 10588).
References


TABLE 1

Distribution and significance of variables within three groups: deaths due to aspiration pneumonia, deaths due to all other causes and subjects who were alive

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>AP</th>
<th>All other</th>
<th>Alive</th>
<th>Log-rank test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>deaths</td>
<td>deaths</td>
<td>n (%)</td>
<td></td>
</tr>
<tr>
<td>Aspiration pneumonia during admission:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Present</td>
<td>79</td>
<td>5 (6)</td>
<td>21 (27)</td>
<td>53 (67)</td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>2120</td>
<td>21 (1)</td>
<td>200 (9)</td>
<td>1899 (90)</td>
<td></td>
</tr>
<tr>
<td>PEG inserted during admission:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Present</td>
<td>311</td>
<td>15 (5)</td>
<td>51 (16)</td>
<td>245 (79)</td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>1381</td>
<td>11 (1)</td>
<td>152 (11)</td>
<td>1218 (88)</td>
<td></td>
</tr>
<tr>
<td>Dysphagia at discharge:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Present</td>
<td>204</td>
<td>15 (7)</td>
<td>44 (22)</td>
<td>145 (71)</td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>1548</td>
<td>11 (1)</td>
<td>153 (10)</td>
<td>1384 (89)</td>
<td></td>
</tr>
<tr>
<td>Rehabilitation length of stay:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≤ 2 months</td>
<td>1645</td>
<td>5 (0.3)</td>
<td>133 (8)</td>
<td>1507 (91)</td>
<td></td>
</tr>
<tr>
<td>&gt; 2 months</td>
<td>900</td>
<td>21 (2)</td>
<td>99 (11)</td>
<td>780 (87)</td>
<td></td>
</tr>
<tr>
<td>FIM discharge total score:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Independent (108-126)</td>
<td>1447</td>
<td>4 (0.3)</td>
<td>103 (7)</td>
<td>1340 (93)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Moderate assist (55-107)</td>
<td>466</td>
<td>6 (1)</td>
<td>40 (9)</td>
<td>420 (90)</td>
<td></td>
</tr>
<tr>
<td>Maximal assist (18-54)</td>
<td>213</td>
<td>13 (6)</td>
<td>44 (21)</td>
<td>156 (73)</td>
<td></td>
</tr>
<tr>
<td>Discharge destination:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Private house</td>
<td>1730</td>
<td>5 (0.3)</td>
<td>133 (8)</td>
<td>1592 (92)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>--------</td>
<td>-----</td>
<td>------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Ongoing rehabilitation</td>
<td>421</td>
<td>3 (1)</td>
<td>40 (10)</td>
<td>378 (89)</td>
<td></td>
</tr>
<tr>
<td>Nursing home</td>
<td>181</td>
<td>18 (10)</td>
<td>47 (26)</td>
<td>116 (64)</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

AP deaths = aspiration pneumonia-related death

PEG = percutaneous endoscopic gastrostomy

FIM = functional independence measure
TABLE 2

Univariate Cox regression analysis identifying significant risk factors for death due to aspiration pneumonia

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>n</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspiration pneumonia during admission</td>
<td>2189</td>
<td>7.76*</td>
<td>2.92-20.6</td>
</tr>
<tr>
<td>PEG inserted during admission</td>
<td>1682</td>
<td>6.98*</td>
<td>3.21-15.2</td>
</tr>
<tr>
<td>Dysphagia at discharge</td>
<td>1744</td>
<td>14.5*</td>
<td>6.60-31.6</td>
</tr>
<tr>
<td>Rehabilitation length of stay</td>
<td>2535</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 2 months (reference group)</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>&gt; 2 months</td>
<td></td>
<td>2.82*</td>
<td>1.74-4.60</td>
</tr>
<tr>
<td>FIM category at discharge:</td>
<td>2120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent (108-126) (reference group)</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Moderate assistance (55-107)</td>
<td></td>
<td>5.37*</td>
<td>1.51-19.1</td>
</tr>
<tr>
<td>Maximal assistance (18-54)</td>
<td></td>
<td>30.3*</td>
<td>9.84-93.5</td>
</tr>
<tr>
<td>Discharge destination:</td>
<td>2323</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private house (reference group)</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ongoing rehabilitation</td>
<td></td>
<td>2.73</td>
<td>0.65-11.46</td>
</tr>
<tr>
<td>Nursing home</td>
<td></td>
<td>46.3*</td>
<td>17.1-125.1</td>
</tr>
</tbody>
</table>

Notes:

*denotes p<0.05

PEG = percutaneous endoscopic gastrostomy

FIM = functional independence measure