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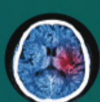

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ORIGINAL ARTICLE

# Healthcare costs of post-stroke oropharyngeal dysphagia and its complications: malnutrition and respiratory infections

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## Abstract

**Background and purpose:** The healthcare economic costs of post-stroke oropharyngeal dysphagia (OD) are not fully understood. The purpose of this study was to assess the acute, subacute and long-term costs related to post-stroke OD and its main complications (malnutrition and respiratory infections).

**Methods:** A cost of illness study of patients admitted to Mataró Hospital (Catalonia, Spain) from May 2010 to September 2014 with a stroke diagnosis was performed. OD, malnutrition and respiratory infections were assessed during hospitalization and follow-up (3 and 12 months). Hospitalization and long-term costs were measured from hospital and healthcare system perspectives. Multivariate linear regression analysis was performed to assess the independent effect of OD, malnutrition and respiratory infections on healthcare costs during hospitalization, and at 3 and 12 months' follow-up.

**Results:** In all, 395 patients were included of whom 178 had OD at admission. Patients with OD incurred major total in-hospital costs (€5357.67 ± €3391.62 vs. €3976.30 ± €1992.58, $p < 0.0001$), 3-month costs (€8242.0 ± €5376.0 vs. €5320.0 ± €4053.0, $p < 0.0001$) and 12-month costs (€11,617.58 ± €12,033.58 vs. €7242.78 ± €7402.55, $p < 0.0001$). OD was independently associated with a cost increase of €789.68 ($p = 0.011$) during hospitalization and of €873.5 ($p = 0.084$) at 3 months but not at 12 months. However, patients with OD who were at risk of malnutrition or malnourished and suffered respiratory infections incurred major mean costs compared with those patients without OD (€19,817.58 ± €13,724.83 vs. €7242.8 ± €7402.6, $p < 0.0004$) at 12 months' follow-up.

**Conclusion:** Oropharyngeal dysphagia causes significant high economic costs during hospitalization that strongly and significantly increase with the development of malnutrition and respiratory infections at long-term follow-up.

**KEYWORDS**
deglutition disorders, economics, malnutrition, respiratory tract infections, stroke

## BACKGROUND

Oropharyngeal dysphagia (OD) is a common complication after stroke [1]. In the acute stroke phase, the incidence of OD is very high (37%–78%) [2] but improves after hospital discharge, remaining as a chronic condition in over 50% of patients [3]. OD impairs the efficacy and the safety of deglutition in acute and long-term stroke patients [4]. This can lead to dehydration, malnutrition and tracheobronchial aspiration that may cause respiratory infections and pneumonia with an associated mortality of up to 50% [1, 4–6]. The main causes of mortality for stroke survivors at 1-year follow-up are respiratory infections and aspiration pneumonia, two well recognized complications of post-stroke OD (PS-OD) [7, 8].

Key aspects of PS-OD management are early evaluation of patient deglutition in the acute phase, compensation of the deficient mechanisms related to the efficacy and safety of deglutition and restoration of the swallowing function [9]. American Heart Association/American Stroke Association guidelines recommend early screening of OD before patients begin eating, drinking or taking oral drugs after acute stroke [10]. Moreover, position statements of the European Society for Swallowing Disorders also recommend screening for OD with a validated tool in the first hours after acute stroke followed by expert assessment if required (videofluoroscopy or fibre optic endoscopic evaluation of swallowing) [11, 12].

A 45.06% prevalence of new-onset dysphagia after stroke was found recently. Moreover, it was found that presenting PS-OD was associated with high mortality rates during hospital stay and was an independent risk factor for prolonged hospital stay and to be institutionalized after hospital discharge; OD was also an independent risk factor for poorer functional capacity and increased risk of mortality 3 months after stroke [13]. OD has also been associated with increased length of stay and mortality during hospitalization, inpatient costs and probability of transfer to a post-acute care facility independent of its aetiology in other studies [14]. Recently, health economic data on the cost of PS-OD have become available [15]. A recent systematic review by our group estimates up to €15,000 (approximately US$16,900) as the cost of PS-OD in the acute phase and €24,000 (approximately US$27,600) as the cost of an episode of pneumonia in patients with PS-OD based on studies performed in France, Switzerland, Argentina, Brazil, Taiwan and the USA. The review revealed few studies describing health economic and social costs of PS-OD after acute hospitalization (subacute and long-term costs) or related to PS-OD complications [16].

The objective of this study was to assess the costs related to OD, malnutrition and respiratory infections after stroke, during hospitalization, and at 3 months' (subacute phase) and 12 months' follow-up (chronic phase) from the hospital and the healthcare system perspectives, respectively. It aims to establish the basis for cost-effectiveness of appropriate PS-OD management to influence healthcare policies.

## METHODS

### Design and study population

This is an observational, longitudinal, cost-of-illness study in two phases: (a) an acute phase that includes a cost analysis of OD after an acute stroke episode during hospitalization from the hospital perspective and (b) a subacute and a chronic phase that includes a cost analysis of OD, malnutrition and the presence of respiratory infections at 3 months' and 12 months' follow-up from the healthcare system perspective.

The study sample included all patients admitted to the Mataró Hospital, Catalonia, Spain, from May 2010 to September 2014 with a confirmed diagnosis of stroke and who gave their written informed consent to participate. Patients were excluded if they had a previous diagnosis of OD, if the final diagnosis on admission was transient ischaemic attack or if they were transferred to another hospital before admission to Mataró Hospital. Recruited patients were classified into two groups according to the presence or absence of OD. The presence of OD was assessed during the first 24–48 h of admission by specially trained nursing staff using the volume–viscosity swallow test previously described by our group [17, 18].

### Cost elements considered (health resource consumption)

#### Phase 1

Acute hospitalization costs included (a) fixed costs (stay in neurology department, stay in intensive care unit and transfers to a tertiary care centre—Hospital Universitari Germans Trias i Pujol, Badalona, Barcelona—for medical attention, revascularization, nursing, imaging and laboratory tests) and (b) variable costs (medication, enteral feeding [EF] and nutritional supplementation [NS]). Medication included fibrinolysis, anticoagulation, antiplatelet inhibitors, acute in-hospital drugs and chronic medication reconciliation during hospital stay.

### Phase 2

Cost in phase 2 comprised subacute (from discharge to 3 months' follow-up) and chronic (from 3 months' to 12 months' follow-up) costs. Subacute and long-term costs included visits to the emergency department, re-hospitalization, stays in a socio-sanitary institution (Hospital de Sant Jaume, Mataró, Barcelona) or in long-term rehabilitation/convalescence facilities (Casal de Curació, Vilassar de Mar, Barcelona) or in a nursing home, and chronic medication. Costs related to institutionalization were based on length of stay at each institution. Costs related to chronic medication were assessed according to electronic prescriptions of the Catalan Health Service and drug consumption during re-hospitalization and socio-sanitary care stay.

## Translation into monetary units (€)

The cost of 1 day in the neurology ward or in the intensive care unit was estimated from price data on diagnosis related groups (brain ischaemia and intracerebral haemorrhage) in the hospital discharge records of the Spanish National Health Services and were considered as €626.38 and €569.78 (brain ischaemia, 201–500 and 501–1000 bed tertiary care hospital, respectively) and €681.88 and €591.96 (intracerebral haemorrhage, 201–500 and 501–1000 bed tertiary care hospital), respectively [19]. Costs related to 1 day in medium-term socio-sanitary centres, long-term rehabilitation/convalescence facilities and nursing homes were estimated from the published public price health agreements of the Catalan Health Service, the Catalan Institute for Social Assistance and Services, the Consorci Sanitari del Maresme (CSdM) and the Fundació Casal de la Salut and were estimated as €92.91, €91.58 and €62.9 respectively [20]. Cost of acute in-hospital medication, EF and NS for each patient was obtained from the billing data of the CSdM Pharmacy Department. Cost attributable to each drug of chronic medication was obtained from the published public prices of reference of the Spanish National Health Services and the Ministerio de Sanidad, Servicios Sociales e Igualdad [21]. All resource use was translated into costs using 2019 unitary values. Cost updates were performed using the corresponding annual Consumer Price Index of Spain provided by the Instituto Nacional de Estadística [22].

## Other study variables

Age and gender, as well as the Charlson Comorbidity Index and the number of comorbidities, the modified Rankin Scale, the Barthel index and the Mini Nutritional Assessment Short Form were assessed and recorded on admission. Stroke type (ischaemic or haemorrhagic) and neurological status using the National Institutes of Health Stroke Scale were assessed. The risk and presence of malnutrition were assessed using the Mini Nutritional Assessment Short Form at 3 months' follow-up. Respiratory infections and/or pneumonia diagnosis at 3 months' and 12 months' follow-up were also collected. Costs for those patients with and without OD who were at risk of or had malnutrition and who developed respiratory infections were also calculated.

## Statistical analysis

The main outcome of interest was the independently associated cost increase for OD, malnutrition and respiratory infections in post-stroke patients. Statistical analysis was performed using GraphPad Prism 6.01 (San Diego, CA, USA). Comparisons of qualitative variables between groups were made using Fisher's exact test or the chi-squared test. Continuous data were presented as mean ± SD and compared between groups with the non-parametric Mann–Whitney *U* test or the Kruskal–Wallis test for multiple comparisons (with Dunn's post-test). To assess normality the D'Agostino and Pearson omnibus normality test was used.

First, a bivariate analysis of the association of OD, malnutrition and risk of malnutrition and the presence of respiratory infections with acute, subacute and chronic healthcare costs was assessed using a simple linear regression analysis. Secondly, a multivariate linear regression analysis was used in three different multivariate models to adjust for the effect of OD, malnutrition or respiratory infections on costs by age, comorbidities, baseline functionality and stroke severity. Statistical significance was set at $p < 0.05$.

## Legal and ethical issues

This research was performed and reported following the recommendations stated in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies [23].

The protocol of this study was evaluated and approved by the Ethical Committee for Clinical Investigation of the Hospital de Mataró (protocol code 35/14), 'La Marató' de TV3 register code 11/2310. All procedures contributing to this investigation were conducted according to the principles stated in the Helsinki Declaration of 1975 and its subsequent amendments. The General Data Protection Regulation of the European Union 2016/679 was followed. All patients included in this study or their legal representative signed an informed consent.

# RESULTS

## Recruitment and main sample characteristics

A total of 608 patients were recruited and 395 were included in the study following eligibility criteria, of whom 178 had OD on admission (45.0%). Figure S1 (Appendix S1) shows the number of individuals at each phase of the study. Descriptive sociodemographic and clinical characteristics of patients included in this study were previously published in a study on the prevalence, risk factors and complications of PS-OD [13, 24]. Table 1 shows a summary of the main sociodemographic, clinical characteristics and nutritional status of patients on admission. A total of 21 patients died during hospitalization and early follow-up (5.31% hospital mortality) and 41 during long-term follow-up (10.38% mortality at long term).

## Health resource consumption in the acute phase

Mean hospitalization days were 7.16 ± 4.30. Patients with OD had longer stays (mean stay, OD 8.33 ± 5.21 days vs. non-OD 6.20 ± 3.05 days; $p < 0.0001$). Also, more patients with OD used EF and NS (patients treated with EF and/or NS, OD 23 (12.92), non-OD 5 (1.26); $p < 0.0001$). A total of seven patients were referred to a tertiary care centre (mean stay, OD 0.08 ± 0.64 days vs. non-OD 0.07 ± 0.50 days; $p < 0.926$). Table S1 shows a summary of patient stays and resource consumption including EF and NS.

## Costs in the acute phase

Mean costs during hospitalization were €4598.79 ± €2799.51 but patients with OD cost significantly more during hospitalization for both fixed and variable costs: hospital stay, €5265.11 ± €3319.62 versus €3902.55 ± €1925.78, $p < 0.0001$; in-hospital medication, €87.86 ± €264.16 versus €73.57 ± €216.25, $p < 0.0001$; EF and/or NS, €4.69 ± €23.28 versus €0.18 ± €1.33, $p < 0.0001$; and total in-hospital costs, €5357.67 ± €3391.62 versus €3976.30 ± €1992.58, $p < 0.0001$, patients with OD being reported first. Table 2 summarizes these findings.

## Health resource consumption in the subacute and chronic phases

In the subacute phase, mean patient visits to the emergency department were 0.16 ± 0.36, and mean stays in re-hospitalizations 0.61 ± 2.3; in a socio-sanitary institution, 6.9 ± 17.5; in a long-term

**TABLE 1** Main sociodemographic and clinical characteristics of the 395 patients included in this study

| OD using V-VST | All patients (*n* = 395) | OD admission (*n* = 178) | Non-OD admission (*n* = 217) | *p* value |
|---|---|---|---|---|
| **Sociodemographic data** | | | | |
| Age, years (mean ± SD) | 73.2 ± 13.3 | 77.9 ± 11.1 | 69.4 ± 13.7 | **<0.0001** |
| Male, *n* (%) | 211 (53.42) | 85 (47.75) | 126 (58.06) | **0.043** |
| **Patient status on admission** | | | | |
| Comorbidity, *n* (%) | | | | |
| No comorbidity, 0 | 35 (8.86) | 9 (5.01) | 26 (11.98) | **0.0008** |
| Moderate comorbidity, 1–2 | 172 (43.54) | 67 (37.64) | 105 (48.39) | |
| Severe comorbidity, ≥3 | 188 (47.59) | 102 (57.30) | 86 (39.63) | |
| CCI, *n* (%) | | | | |
| 0–1 | 111 (28.10) | 34 (19.10) | 77 (35.48) | **0.002** |
| 2 | 108 (27.34) | 55 (30.89) | 53 (24.42) | |
| ≥3 | 176 (44.55) | 89 (50.00) | 87 (40.09) | |
| Barthel index (mean ± SD) | 91.00 ± 18.41 | 85.28 ± 23.59 | 95.69 ± 10.64 | **<0.0001** |
| Barthel ≤ 90, *n* (%) | 105 (26.58) | 68 (38.2) | 37 (17.05) | **<0.0001** |
| mRS (mean ± SD) | 0.78 ± 1.38 | 1.16 ± 1.57 | 0.47 ± 1.10 | **<0.0001** |
| mRS > 1, *n* (%) | 93 (23.54) | 62 (34.83) | 31 (14.29) | **<0.0001** |
| NIHSS admission (mean ± SD) | 5.06 ± 6.04 | 8.10 ± 7.60 | 2.56 ± 2.30 | **<0.0001** |
| NIHSS admission >6, *n* (%) | 42 (10.63) | 27 (15.17) | 15 (6.91) | **0.009** |
| | **All patients (*n* = 266)** | **OD admission (*n* = 114)** | **Non-OD admission (*n* = 152)** | |
| **Nutritional status on admission** | | | | |
| MNA-sf (mean ± SD) | 12.18 ± 2.04 | 11.87 ± 1.97 | 12.41 ± 1.76 | **0.023** |
| Well-nourished (12–14), *n* (%) | 174 (65.41) | 68 (59.65) | 106 (69.74) | 0.190 |
| At risk (8–11), *n* (%) | 80 (30.08) | 39 (34.21) | 41 (26.97) | |
| Malnourished (0–7), *n* (%) | 12 (4.51) | 7 (6.14) | 5 (3.29) | |

Bold indicates statistical significance value ($p < 0.05$).

Abbreviations: CCI, Charlson Comorbidity Index; MNA-sf, Mini Nutritional Assessment Short Form; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; OD, oropharyngeal dysphagia; V-VST, volume–viscosity swallow test.

**TABLE 2** Total mean direct healthcare related and non direct healthcare related costs during acute in-hospital admission, and at 12 months' follow-up (euros, 2019)

| OD using V-VST | All patients ($n = 395$) | OD ($n = 178$) | Non-OD ($n = 217$) | $p$ value |
|---|---|---|---|---|
| **Acute in-hospital costs** | | | | |
| Hospitalization (ICU + neurology ward + tertiary hospital) | 4516.57 ± 2731.84 | 5265.11 ± 3319.62 | 3902.55 ± 1925.78 | **<0.0001** |
| Medication | 80.01 ± 254.57 | 87.86 ± 264.16 | 73.57 ± 216.25 | **<0.0001** |
| Enteral feeding and nutritional supplementation | 2.21 ± 15.82 | 4.69 ± 23.28 | 0.18 ± 1.33 | **<0.0001** |
| Total | 4598.79 ± 2799.51 | 5357.67 ± 3391.62 | 3976.30 ± 1992.58 | **<0.0001** |
| **OD using V-VST** | **All patients ($n = 374$)** | **OD ($n = 158$)** | **Non-OD ($n = 216$)** | |
| **Subacute costs (3 months' follow-up)** | | | | |
| Direct healthcare and direct non-healthcare costs | | | | |
| Chronic medication | 232.3 ± 270.3 | 265.7 ± 296.8 | 207.9 ± 247.0 | **0.036** |
| Re-hospitalization | 388.6 ± 2055.4 | 416.3 ± 1651.0 | 368.3 ± 2310.0 | 0.163 |
| In-hospital medication cost | 4.7 ± 50.4 | 3.8 ± 19.9 | 5.4 ± 64.1 | 0.226 |
| In-hospital enteral feeding and nutritional supplementation | 0.02 ± 0.35 | 0.04 ± 0.50 | 0.01 ± 0.2 | 0.824 |
| Emergency department | 14.4 ± 33.2 | 11.0 ± 29.7 | 16.9 ± 35.4 | 0.090 |
| Socio-sanitary care | 641.7 ± 1628.6 | 992.6 ± 1946.0 | 385.0 ± 1296.0 | **0.0002** |
| Long-term rehabilitation facilities | 221.1 ± 1270.8 | 266.0 ± 1401.0 | 188.2 ± 1169.0 | 0.582 |
| Nursing home | 458.6 ± 1402.9 | 843.6 ± 1798.0 | 177.1 ± 930.3 | **<0.0001** |
| Total | 1961.4 ± 3284.5 | 2799.0 ± 3395.0 | 1349.0 ± 3067.0 | **<0.0001** |
| Total (admission + subacute) | 6554.3 ± 4870.7 | 8242.0 ± 5376.0 | 5320.0 ± 4053.0 | **<0.0001** |
| **Long-term costs (12 months' follow-up)** | | | | |
| Direct healthcare and direct non-healthcare costs | | | | |
| Chronic medication | 881.75 ± 961.48 | 936.94 ± 893.07 | 841.38 ± 1.006.67 | 0.169 |
| Re-hospitalization | 930.84 ± 4.423.50 | 1083.76 ± 5.985.29 | 818.98 ± 2765.23 | 0.970 |
| In-hospital medication cost | 10.73 ± 84.88 | 14.98 ± 104.50 | 7.64 ± 66.98 | 0.875 |
| In-hospital enteral feeding and nutritional supplementation | 0.09 ± 1.48 | 0.21 ± 2.21 | 0.01 ± 0.18 | 0.389 |
| Emergency department | 64.49 ± 120.49 | 64.52 ± 125.98 | 64.48 ± 116.30 | 0.162 |
| Socio-sanitary care | 716.69 ± 2.146.19 | 1156.67 ± 2.834.90 | 394.86 ± 1360.72 | **0.0002** |
| Long-term rehabilitation facilities | 428.76 ± 2.820.82 | 395.30 ± 2.243.84 | 453.24 ± 3176.97 | 0.597 |
| Nursing home | 1464.53 ± 5.002.62 | 2522.37 ± 6392.77 | 690.73 ± 3467.16 | **<0.0001** |
| Total | 4497.89 ± 8839.78 | 6174.68 ± 10,957.68 | 3271.34 ± 6626.48 | **<0.0001** |
| **Acute and long-term direct healthcare and non-healthcare costs** | | | | |
| 1-year total costs | 9090.88 ± 9873.82 | 11,617.58 ± 12,033.58 | 7242.78 ± 7402.55 | **<0.0001** |

Bold indicates statistical significance value ($p < 0.05$).

Abbreviations: ICU, intensive care unit; OD, oropharyngeal dysphagia; V-VST, volume–viscosity swallow test.

rehabilitation/convalescence facility, 2.4 ± 13.9; and in nursing homes, 7.3 ± 22.3. Significantly higher patient stays in socio-sanitary institutions (10.7 ± 20.9 days vs. 4.1 ± 14.00 days, $p = 0.0002$) and nursing homes (13.4 ± 28.6 days vs. 2.8 ± 17.8 days, $p < 0.0001$) were observed for patients with OD.

At 12 months' follow-up, mean patient visits to the emergency department were 0.71 ± 1.32, and mean stays in re-hospitalizations 1.47 ± 7.02; in a socio-sanitary institution, 7.71 ± 23.09; in a long-term rehabilitation/convalescence facility, 4.69 ± 30.84; and in nursing homes, 23.28 ± 79.53. Significantly higher patient stays in socio-sanitary institutions (12.45 ± 30.51 days vs. 4.25 ± 14.64 days, $p = 0.0002$) and nursing homes (40.10 ± 101.63 days vs. 10.98 ± 55.12 days, $p < 0.0001$) were observed for patients with PS-OD. Table S1 summarizes long-term resource consumption of the variables measured in this study.

## Costs in the subacute and chronic phases

At 3 months' follow-up, mean costs were €6554.3 ± €4870.7 per patient. The only significant differences found between patients with and without PS-OD were related to socio-sanitary care (€992.6 ± €1946.0 vs. €385.0 ± €1296.0, $p = 0.0002$) and nursing homes (€843.6 ± €1798.0 vs. €177.1 ± €930.3, $p < 0.0001$), higher for patients with PS-OD. At 3 months' follow-up, total costs (acute plus subacute direct healthcare and non-healthcare costs) were higher for those patients with PS-OD (€8242.0 ± €5376.0 vs. €5320.0 ± €4053.0, $p < 0.0001$).

At 12 months' follow-up, mean costs were €9090.88 ± €9873.82 per patient. Although there was a constant trend towards higher costs related to chronic medication, re-hospitalizations, in-hospital EF and NS and visits to the emergency department, no significant differences were found between those patients with PS-OD and those without. Costs related to socio-sanitary care (€1156.67 ± €2834.90 vs. €394.86 ± €1360.72, $p = 0.0002$) and nursing homes (€2522.37 ± €6392.77 vs. €690.73 ± €3467.16, $p < 0.0001$) were higher for patients with PS-OD. At 12 months of follow-up, total costs (acute plus long-term direct healthcare and non-healthcare costs) were higher for those patients with PS-OD (€11,617.58 ± €12,033.58 vs. €7242.78 ± €7402.55, $p < 0.0001$). Table 2 summarizes these findings.

## Resource consumption and costs associated with nutritional risk or malnutrition on admission and at 3 months' follow-up

Patients at risk of malnutrition or malnourished on admission had significantly higher hospital stays (8.4 ± 4.8 days vs. 6.9 ± 4.2 days, $p = 0.004$) and EF and NS consumption (9.8% vs. 2.3%, $p = 0.013$) and incurred major costs (€5370.0 ± €3052.0 vs. €4445.0 ± €2759.0, $p = 0.004$) during acute hospitalization and at 3 months' follow-up (€8145.0 ± €5868.0 vs. €5830.0 ± €4204.0, $p = 0.001$). Table 3 shows a summary of the main sociodemographic and clinical characteristics and nutritional status of patients on admission. At 3 months' follow-up, 69 out of 231 patients (29.8%) that could be evaluated were at risk of malnutrition or malnourished, with more visits to the emergency department (1.0 ± 1.4 vs. 0.67 ± 1.2, $p = 0.029$) and stays in nursing homes (47.1 ± 118.1 days vs. 4.3 ± 38.8 days, $p < 0.0001$) at 1-year follow-up without significant differences on stays related to re-hospitalizations, socio-sanitary institution and long-term rehabilitation/convalescence facilities. Table S2 summarizes acute and long-term resource consumption and its

**TABLE 3** Main sociodemographic and clinical characteristics of the patients included in the study with and without malnutrition or risk of malnutrition

| Risk MN/MN using MNA-sf | All patients (*n* = 395) | Risk MN/MN (*n* = 92) | No risk MN/MN (*n* = 174) | *p* value |
|---|---|---|---|---|
| **Sociodemographic data** | | | | |
| Age, years (mean ± SD) | 73.2 ± 13.3 | 75.0 ± 12.5 | 70.9 ± 12.7 | **0.008** |
| Male, *n* (%) | 211 (53.42) | (41) | (112) | **0.003** |
| **Patient status before admission** | | | | |
| Comorbidity, *n* (%) | | | | |
| No comorbidity, 0 | 35 (8.86) | 12 (13.0) | 8 (4.6) | **0.037** |
| Moderate comorbidity, 1–2 | 172 (43.54) | 37 (40.2) | 84 (48.3) | |
| Severe comorbidity, ≥3 | 188 (47.59) | 43 (46.7) | 82 (47.1) | |
| CCI, *n* (%) | | | | |
| 0–1 | 111 (28.10) | 21 (22.8) | 54 (31.0) | 0.346 |
| 2 | 108 (27.34) | 29 (31.5) | 46 (26.4) | |
| ≥3 | 176 (44.55) | 42 (45.7) | 74 (42.5) | |
| Barthel index (mean ± SD) | 91.00 ± 18.41 | 86.9 ± 21.6 | 95.7 ± 10.2 | **<0.0001** |
| Barthel ≤ 90, *n* (%) | 105 (26.58) | 33 (35.9) | 29 (16.7) | **0.0007** |
| mRS (mean ± SD) | 0.78 ± 1.38 | 0.9 ± 1.5 | 0.4 ± 1.0 | **0.002** |
| mRS > 1, *n* (%) | 93 (23.54) | 25 (27.2) | 24 (13.8) | **0.012** |
| NIHSS admission (mean ± SD) | 5.06 ± 6.04 | 5.3 ± 5.6 | 3.6 ± 3.9 | **0.012** |
| NIHSS admission >6, *n* (%) | 42 (10.63) | 22 (23.9) | 25 (14.4) | 0.063 |

Bold indicates statistical significance value ($p < 0.05$).

Abbreviations: CCI, Charlson Comorbidity Index; MN, malnutrition; MNA-sf, Mini Nutritional Assessment Short Form; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale.

relation with nutritional status. Long-term costs were significantly higher for those patients at risk of malnutrition or malnourished compared with well-nourished patients (€10,678.0 ± €10,466.9 vs. €6230 ± €4326.0, $p$ = 0.01). Table 4 summarizes these findings. Table 5 summarizes differences in costs between those patients with and without OD and with and without risk of malnutrition or malnutrition.

## Respiratory infections at 1-year follow-up and their influence on costs

Sixty-two out of 374 patients (16.6%) who underwent the 1-year follow-up suffered at least one episode of respiratory infection (78 episodes in total, mean 1.26/affected patient) and incurred significantly higher long-term costs (€13,806.0 ± €11,834.0 vs. €8154.0 ± €9190.0, $p < 0.0001$). Table 5 summarizes differences in costs between patients with and without PS-OD and with or without respiratory infections.

## Total acute and long-term costs on those patients who suffered from OD and its complications

Those patients with PS-OD and at risk of malnutrition or malnourished at 3 months' follow-up incurred higher costs at 12 months' follow-up than patients without PS-OD (€14,295.6 ± €11,334.5 vs. €7242.8 ± €7402.6, $p < 0.001$). Patients with PS-OD and respiratory infection incurred higher costs than patients without PS-OD (€16,487.0 ± €11,603.9 vs. €7242.8 ± €7402.6, $p < 0.0001$) at 12 months' follow-up. Patients with PS-OD at risk of or malnourished who had a respiratory infection incurred greater mean costs than patients without PS-OD (€19,817.58 ± €13,724.83 vs. €7242.8 ± €7402.6, $p < 0.0004$) at 12 months' follow-up. Table 6 shows a comparison of mean costs between patients with and without PS-OD, risk of or malnutrition, and respiratory infections.

## Multivariate analysis

After adjusting for possible confounding factors, OD was independently associated with an increased cost of €789.68 ($p$ = 0.011) during hospitalization in the acute phase and €873.5 ($p$ = 0.084) in the subacute phase but no significant effect was observed in the chronic phase. For nutritional status, moving from one category (well-nourished, at risk of malnutrition and malnourished) to the next, worse one, was independently associated with a cost increase of €1277.39 ($p$ = 0.004) at subacute phase and of €2303.38 ($p$ = 0.001) at chronic phase. The presence of at least one respiratory infection was independently associated with a cost increase of €3792.62 ($p < 0.001$) in the subacute phase and of €3034.08 ($p < 0.011$) in the chronic phase. Results of the multivariate analysis are described in Table S3.

## Costs from the hospital and the healthcare system perspectives

In the case of patients with PS-OD, mean hospitalization costs (hospital perspective) were lower than costs outside acute hospitalization (health care system perspective) (€5357.67 ± €3391.62 vs. €6174.68 ± €10,957.68, respectively), whilst in those patients without OD mean hospitalization costs were higher than subacute and chronic costs (€3976.30 ± €1992.58 vs. €3271.34 ± €6626.48, respectively). In the case of patients affected or not by risk of malnutrition or malnutrition, chronic costs were higher in both cases compared to hospitalization costs (€2945.00 ± €4593.00 vs. €6029.00 ± €9018.00 and €1384.00 ± €2397.00 vs. €2120.00 ± €3494.00, respectively).

# DISCUSSION

This study shows a significant and independent increase in health economic costs of €789.68 during hospitalization for patients with PS-OD, and €873.5 at 3 months' follow-up. Patients with poor nutritional status at 3 months showed a significant and independent cost increase of €2303.38 at 12 months' follow-up, and for patients with at least one respiratory infection at 3 and 12 months' follow-up the costs were increased by €3792.62 and €3034.08, respectively. This shows an independent increase in costs associated with PS-OD during hospitalization that can increase exponentially with the development of its main complications (malnutrition and respiratory infections) during long-term follow-up. The 1-year cost of a patient with PS-OD, malnutrition and at least one episode of respiratory infection is €19,817.58 ± €13,724.83 versus €7242.8 ± €7402.6 for post-stroke patients without OD, a clear indication of the economic burden of PS-OD from both the hospital and the healthcare system perspective.

In this study, about half the costs incurred by our post-stroke patients were attributed to acute hospitalization. Significant mean cost increases were observed for patients with PS-OD (€5357.67 ± €3391.62 vs. €3976.30 ± €1992.58) and patients at risk of malnutrition or malnourished on stroke admission (€5370.0 ± €3052.0 vs. €4445.0 ± €2759.0), mainly due to longer hospital stays (8.33 ± 5.21 vs. 6.20 ± 3.05 days and 8.40 ± 4.80 vs. 6.90 ± 4.20 days respectively). These data coincide with a previously published systematic review that assessed the influence of OD secondary to all aetiologies on length of stay and costs finding that PS-OD patients had a longer and more variable length of stay of 4.73 days (95% confidence interval 2.7–7.2) and an increase of 40.36% in costs [25]. Moreover, previous studies showed an increase of €3000 on hospitalization costs for patients with ischaemic PS-OD in France and of 14,000 Swiss Francs in Switzerland [26], and an increase of approximately US$6589 on patients needing tube feeding after ischaemic or haemorrhagic stroke in the USA [27]. In patients transferred to a rehabilitation ward after haemorrhagic stroke, OD has been identified as a significant predictor of the total medical costs using a stepwise multivariate analysis with a

**TABLE 4** Total mean direct healthcare related and non direct healthcare related costs during acute in-hospital admission and at 12 months' follow-up

| Risk of MN/MN at admission | All patients ($n = 395$) | Risk MN/MN ($n = 92$) | No risk MN/MN ($n = 174$) | $p$ value |
|---|---|---|---|---|
| **Acute in-hospital costs** | | | | |
| Hospitalization (ICU + neurology ward + tertiary hospital) | 4516.57 ± 2731.84 | 5321.0 ± 3038.0 | 4350.0 ± 2655.0 | **0.004** |
| Medication | 80.01 ± 254.57 | 46.6 ± 149.0 | 93.3 ± 294.8 | **0.007** |
| Enteral feeding and nutritional supplementation | 2.21 ± 15.82 | 3.2 ± 14.3 | 2.4 ± 21.1 | **0.013** |
| Total | 4598.79 ± 2799.51 | 5370.0 ± 3052.0 | 4445.0 ± 2759.0 | **0.004** |
| **Risk of MN/MN at admission** | **All patients ($n = 374$)** | **Risk MN/MN ($n = 88$)** | **No risk MN/MN ($n = 174$)** | |
| **Subacute costs (3 months' follow-up)** | | | | |
| Direct healthcare and direct non-healthcare costs | | | | |
| Chronic medication | 232.3 ± 270.3 | 260.9 ± 295.6 | 236.4 ± 275.8 | 0.344 |
| Re-hospitalization | 388.6 ± 2055.4 | 797.2 ± 3534.0 | 237.6 ± 1250.0 | 0.177 |
| In-hospital medication cost | 4.7 ± 50.4 | 12.7 ± 100.1 | 2.1 ± 15.4 | 0.188 |
| In-hospital enteral feeding and nutritional supplementation | 0.02 ± 0.35 | 0.03 ± 0.3 | 0.04 ± 0.5 | 1.000 |
| Emergency department | 14.4 ± 33.2 | 13.5 ± 32.5 | 13.6 ± 32.6 | 1.000 |
| Socio-sanitary care | 641.7 ± 1628.6 | 821.4 ± 1998.0 | 575.1 ± 1310.0 | 0.963 |
| Long-term rehabilitation facilities | 221.1 ± 1270.8 | 368.4 ± 1596.0 | 142.1 ± 1076.0 | 0.123 |
| Nursing home | 458.6 ± 1402.9 | 671.2 ± 1654.0 | 177.5 ± 932.2 | **0.0002** |
| Total | 1961.4 ± 3284.5 | 2945.0 ± 4593.0 | 1384.0 ± 2397.0 | **0.022** |
| Total (admission + subacute) | 6554.3 ± 4870.7 | 8145.0 ± 5868.0 | 5830.0 ± 4204.0 | **0.001** |
| **Risk of MN/MN assessed at 3 months' follow-up** | **All patients ($n = 374$)** | **Risk MN/MN ($n = 69$)** | **No risk MN/MN ($n = 162$)** | |
| **Long-term costs (12 months' follow-up)** | | | | |
| Direct healthcare and direct non-healthcare costs | | | | |
| Chronic medication | 881.75 ± 961.48 | 993.4 ± 746.1 | 884.4 ± 1060.0 | **0.048** |
| Re-hospitalization | 930.84 ± 4.423.50 | 930.6 ± 2837.0 | 478.0 ± 1664.0 | 0.358 |
| In-hospital medication cost | 10.73 ± 84.88 | 17.51 ± 113.4 | 3.2 ± 24.5 | 0.363 |
| In-hospital enteral feeding and nutritional supplementation | 0.09 ± 1.48 | 0.0 ± 0.0 | 0.0 ± 0.0 | 1.000 |
| Emergency department | 64.49 ± 120.49 | 93.7 ± 126.8 | 61.3 ± 111.5 | **0.029** |
| Socio-sanitary care | 716.69 ± 2.146.19 | 681.3 ± 1719.0 | 421.0 ± 1357.0 | 0.068 |
| Long-term rehabilitation facilities | 428.76 ± 2.820.82 | 526.9 ± 3089.0 | 0.0 ± 0.0 | 0.088 |
| Nursing home | 1464.53 ± 5002.62 | 2965.0 ± 7431.0 | 271.8 ± 2441.0 | <**0.0001** |
| Total | 4497.89 ± 8839.78 | 6029.0 ± 9018.0 | 2120.0 ± 3494.0 | **0.0008** |
| **Acute and long-term direct healthcare and non-healthcare costs** | | | | |
| 1-year total costs according to risk or malnutrition at 3-month follow-up | 9090.88 ± 9873.82 | 10,678.0 ± 10,446.0 | 6230.0 ± 4326.0 | **0.010** |

Bold indicates statistical significance value ($p < 0.05$).
Abbreviations: ICU, intensive care unit; MN, malnutrition.

beta coefficient of 1025.8 (95% confidence interval 193.9–1857.8, $p < 0.001$) in Taiwan [28].

To our knowledge, the only study that has previously reported data on the long-term adjusted effect of PS-OD on sanitary costs was performed by Bonilha et al. in the USA. This study reported an adjusted incremental cost at 1-year follow-up of US$4510 for Medicare for patients with ischaemic PS-OD [29]. In the case of respiratory infections, five previous retrospective studies reported

**TABLE 5** Chronic, 12 months' follow-up mean total cost of patients with PS-OD, patients at risk of malnutrition/malnutrition at 3 months' follow-up and patients with respiratory tract infections

**Acute and long-term direct healthcare and non-healthcare costs**

| | | All patients ($n = 374$) | Risk MN/MN ($n = 69$) | Well-nourished ($n = 162$) | Non-OD ($n = 216$) | OD ($n = 158$) |
|---|---|---|---|---|---|---|
| **Comparison between OD and risk of MN/MN** | | | | | | |
| 1-year total costs | | 9090.88 ± 9873.82 | 10,678.0 ± 10,446.0 | 6230.0 ± 4326.0 | 7242.8 ± 7402.6 | 11,617.6 ± 12,033.6 |
| *p* value | Risk MN/MN | | | ** | * | ns |
| | Well-nourished | | | | ns | **** |
| | Non-OD | | | | | **** |
| | OD | | | | | |

| | | All patients ($n = 374$) | RTI ($n = 62$) | Non-RTI ($n = 312$) | Non-OD ($n = 216$) | OD ($n = 158$) |
|---|---|---|---|---|---|---|
| **Comparison between OD and RTI** | | | | | | |
| 1-year total costs | | 9090.88 ± 9873.82 | 13,806.0 ± 11,834.0 | 8154.0 ± 9190.0 | 7242.8 ± 7402.6 | 11,617.6 ± 12,033.6 |
| *p* value | RTI | | | *** | **** | ns |
| | Non-RTI | | | | ns | **** |
| | Non-OD | | | | | **** |
| | OD | | | | | |

Abbreviations: MN, malnutrition; OD, oropharyngeal dysphagia; RTI, respiratory tract infection.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

**** $p < 0.0001$.

cost increases between US$1456 and US$27,633 during hospitalization after stroke on patients who developed pneumonia, but did not study beyond acute hospitalization [28, 30–33]. Regarding malnutrition, the prospective study performed by Gomes et al. reported an increase in costs during hospitalization at 6 months after stroke for patients at high risk of malnutrition in the UK (£8720 vs. £4920, $p < 0.001$) [34].

In our patients with PS-OD, total mean hospitalization costs (acute phase) were lower than subacute and long-term chronic costs (subacute and chronic phases) whilst in patients without PS-OD most costs occurred during hospitalization. The multivariate analysis showed that the long-term costs of OD could be more related to its complications (malnutrition and respiratory infections) and the costs during hospitalization due to its effect on resource consumption. This would explain why the chronification of OD together with the appearance of its long-term complications is the main explanation for the exponential increase of costs in these patients.

The early and appropriate management of PS-OD patients is essential in the acute phase of hospitalization and the subacute and chronic phases of patient rehabilitation. These data agree with a previously published systematic review on PS-OD but add insights into the costs of OD beyond acute admission, and the impact of malnutrition and respiratory infections, which are direct consequences of OD [15, 16]. The data provided in this study could be a first step to study the cost-effectiveness of appropriate management of these complications. Considering that OD, malnutrition and respiratory infections are associated with higher costs after stroke, massive screening and specialized management of patients with PS-OD and malnutrition could significantly improve patient outcome and cost-effectiveness. A recent Cochrane review on the treatment of PS-OD concluded that, whilst new treatment strategies improved swallowing parameters, they seemed not enough to reduce clinical outcomes such as mortality or respiratory infections [35]. Early screening after admission, accurate clinical and instrumental assessment and appropriate compensatory and rehabilitation strategies would reduce dysphagia costs and complications in post-stroke patients.

Costs of PS-OD comprise acute in-hospital and long-term sanitary and social costs related to nutritional and respiratory complications, but also direct non-healthcare costs and indirect costs associated with loss of patient productivity and other unknown intangible costs. In addition, the healthcare expenses related to instrumental diagnosis and treatment of PS-OD should also be considered. In centres with protocols using instrumental explorations (videofluoroscopy or fibre optic endoscopic evaluation of swallowing), the costs of these explorations during the acute phase must be added. In centres using behavioural intervention provided by speech and language therapists or neurorehabilitation strategies (electrical or pharmacological), the cost of these treatments must also be considered for patients with PS-OD. Costs related to patient stays were estimated from public prices. Costs related to patient mortality

**TABLE 6** Mean total cost of PS-OD including respiratory tract infections and risk of malnutrition/malnutrition (3 months)

| OD V-VST | All patients ($n = 374$) | Non-OD admission ($n = 216$) | Non-OD+RTI ($n = 28$) | Non-OD+risk MN/MN ($n = 40$) | Non-OD non-RTI ($n = 188$) | Non-OD non-risk MN/MN ($n = 103$) | OD ($n = 158$) | OD + RTI ($n = 34$) | OD + risk MN/MN 3m ($n = 29$) | OD non-RTI ($n = 124$) | OD + non-risk MN/MN ($n = 59$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Acute and long-term direct healthcare and non-healthcare costs** | | | | | | | | | | | |
| 1-year total costs | 9090.9 ± 9873.8 | 7242.8 ± 7402.6 | 10,550.0 ± 11,260.0 | 8055.0 ± 8829.0 | 6750.0 ± 6566.0 | 5726.0 ± 4070.0 | 11,617.6 ± 12,033.6 | 16,487.0 ± 11,603.9 | 14,295.6 ± 11,334.5 | 10,282.0 ± 11,851.0 | 7111.0 ± 4645.0 |
| *p* value | Non-OD | | ns | ns | ns | ns | **** | **** | *** | ** | ns |
| | Non-OD + RTI | | | ns | ns | ns | ns | ns | ns | ns | ns |
| | Non-OD + MN | | | | ns | ns | ns | ** | * | ns | ns |
| | Non-OD – RTI | | | | | ns | **** | **** | *** | *** | ns |
| | Non-OD – MN | | | | | | **** | **** | *** | *** | ns |
| | OD | | | | | | | ns | ns | ns | ns |
| | OD + RTI | | | | | | | | ns | ns | ** |
| | OD + MN | | | | | | | | | ns | ns |
| | OD – RTI | | | | | | | | | | ns |
| | OD – MN | | | | | | | | | | |

Abbreviations: MN, malnutrition; OD, oropharyngeal dysphagia; PS-OD, post-stroke oropharyngeal dysphagia; RTI, respiratory tract infection; V-VST, volume–viscosity swallow test.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

**** $p < 0.0001$.

were not measured which could lead to an artificial reduction of the real cost of the dysphagia group, as they had a significantly higher mortality. This study was performed at Mataró Hospital, a 300-bed community hospital near Barcelona that serves more than 275,000 inhabitants. Management of all types of strokes is performed at the emergency room and neurology ward by specialized nursing and medical teams and at the intensive care unit if required. Strokes can be treated with thrombolysis and transferred to our referral centre if thrombectomy is required. The results of a prospective stroke registry of patients admitted to Mataró Hospital during the last 10 years describing the main clinical characteristics and the outcomes of treatment have been published [36].

In summary, this study shows increased costs—direct and resource consumption—during hospitalization and long-term follow-up in patients with PS-OD and/or its main complications, malnutrition and respiratory infections. Future studies are needed to assess cost savings related to the correct management of PS-OD, malnutrition and the risk of aspiration which can cause pneumonia. This increase in the economic costs of OD is also a reflection of the severe clinical consequences for stroke patients with these complications.

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## CONFLICT OF INTEREST

The authors affirm that there are no conflicts of interest. The sponsors had no role in the design or development of this study.

## AUTHOR CONTRIBUTIONS

Sergio Marin: Conceptualization (lead); data curation (lead); formal analysis (lead); investigation (lead); methodology (lead); software (lead); supervision (lead); validation (lead); visualization (lead); writing—original draft (lead); writing—review and editing (lead). Mateu Serra-Prat: Conceptualization (lead); data curation (lead); formal analysis (lead); investigation (lead); methodology (lead); resources (supporting); software (supporting); supervision (lead); validation (lead); visualization (lead); writing—original draft (supporting); writing—review and editing (supporting). Omar Ortega Fernández: Conceptualization (lead); data curation (lead); formal analysis (lead); investigation (lead); methodology (lead); software (lead); supervision (lead); validation (lead); visualization (lead); writing—original draft (supporting); writing—review and editing (supporting). Monica Audouard Fericgla: Data curation (supporting); formal analysis (supporting); investigation (supporting); methodology (supporting); software (supporting); validation (supporting); writing—review and editing (supporting). Jordi Valls: Conceptualization (supporting); data curation (supporting); formal analysis (supporting); investigation (supporting); methodology (lead); resources (supporting); supervision (supporting); validation (supporting). Elisabet Palomera: Conceptualization (supporting); data curation (supporting); formal analysis (supporting); investigation (supporting); methodology (supporting); software (supporting); supervision (supporting); validation (supporting). Ramon Cunillera: Conceptualization (supporting); data curation (supporting); formal analysis (supporting); investigation (supporting); methodology (lead); resources (supporting); supervision (supporting); validation (supporting). Ernest Palomeras: Conceptualization (supporting); data curation (supporting); formal analysis (supporting); investigation (supporting); methodology (lead); resources (supporting); supervision (supporting); validation (supporting). Josep Maria Ibáñez: Conceptualization (supporting); data curation (supporting); formal analysis (supporting); investigation (supporting); methodology (lead); resources (supporting); supervision (supporting); validation (supporting). Pere Clave: Conceptualization (lead); data curation (lead); formal analysis (lead); funding acquisition (lead); investigation (lead); methodology (lead); project administration (lead); resources (lead); software (lead); supervision (lead); validation (lead); visualization (lead); writing—original draft (lead); writing—review and editing (lead).

## DATA AVAILABILITY STATEMENT

Due to the sensitive nature of the data collected for this study, requests to access the dataset from qualified researchers trained in human subject confidentiality protocols may be sent to CSdM at Professor Pere Clavé, Director of Research and Innovation.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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