Research, Audit and Clinical Practice

Does admission via an Acute Medical Unit influence hospital mortality? 12 years' experience in a large Dublin Hospital

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Abstract

Background: *Following an emergency medical admission, patients may be admitted an acute medical assessment unit (AMAU) or directly into a ward. An AMAU provides a structured environment for their initial assessment and treatment.*
Methods: *All emergency admissions (66,933 episodes in 36,271 patients) to an Irish hospital over an 12-year period (2002-2013) were studied with 30-day in-hospital mortality as the outcome measure. Univariate Odds Ratios, by initial patient allocation, and the fully adjusted Odds Ratios were calculated, using a validated logistic regression model.*
Results: *Patients, by design, were intended to be admitted initially to the AMAU (<= 5 day stay). Capacity constraints dictated that only 39.8% of patients were so admitted; the remainder bypassed the AMAU to a ward (60.2%). All patients remained under the care of the admitting consultant/team. We computed the risk profile for each group, using a multiple variable validated model of 30-day in-hospital mortality; the model indicated the same risk profile between these groups. The univariate OR of an in-hospital death by day 30 for a patient initially allocated to the AMAU, compared with an initial ward allocation was 0.76 (95% CI: 0.71, 0.82- p<0.001). The fully adjusted risk for patients was 0.67 (95% CI: 0.62, 0.73- p<0.001).*
Conclusion: *Patients, with equivalent mortality risk, allocated initially to AMAU or a more traditional ward, appeared to have substantially different outcomes.*

Keywords

Mortality, Emergency Medical Admission, Structured, Routine Care, Outcomes

Key points

1. Structured systems of care for conditions such as stroke and heart attack are well established.
2. Acute medicine developed to deliver more organised and effective care to emergency medical admissions.
3. This paper outlines that patients admitted into structured AMAU care are 36% less likely to die than patients admitted directly to a general ward.
4. Ongoing vigilance is required to ensure that changing systems of care deliver optimal outcome for patients.

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Introduction

Acute medicine focuses on the immediate management of patients requiring emergency admission.[1] The process of care influences patient outcomes and and the development of acute medical admissions units (AMAU) has been a priority of health care reform. St James's Hospital (SJH), Dublin, Ireland established an AMAU in 2003 and has reported short and long-term outcome.[2-4] The benefits of such structural reform[5, 6] and senior consultant interventions for Acute Medicine have been well documented.[5] Changes in demographic, combined with the complex medical needs of an ageing population necessitates investment in the delivery of acute care intrinsically linked to emergency medical admissions.

Health trends suggest increased life expectancies with shifts from acute to chronic 'disabling' conditions. Where life expectancy has increased by 4.0 and 2.6 years for males and females respectively from 1970-2010, time spent with a chronic 'disabling' condition increased by 9.2 and 9.4 years for males and females respectively in the same time period.[7] Consequently, the complexity and costs of acute healthcare delivery can be anticipated to increase. This leads naturally to the study of factors that may be modulated with a view to maximizing the efficiency and minimizing the waste of our health services. Targets may be set with a view to incentivising efficiency or in the belief that these may a proxy of a measure of quality.[8]

Hospital capacity constraints can result in congestion in the emergency department with adverse outcomes;[11] there may be consequential political pressures, in response to media and public concerns thus influencing Health Sector Targets. The unintended consequence of these may be to move patients into the first available ward - rather than allocation to a suitable bed related to the medical and nursing need.[8] The decision on the

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route adopted through hospital wards during the clinical episode, is typically made by administrative staff; such decisions are not necessarily informed by the medical team in charge of the patient.

The emphasis of care has to date been on getting a consultant engaged with the care earlier;[5] an additional consideration is that more experienced practitioners appeared to achieve better outcomes.[9] We set out to determine whether initial ward allocation (between AMAU and other wards) could influence patient outcome. We have examined the last 12 yr of acute medical admissions at St James' Hospital, Dublin with a view to determining how the initial ward allocation might have influenced the 30 day in-hospital mortality.

Methods

Background

St James's Hospital (SJH) serves as a secondary care centre for emergency admissions for its local Dublin catchment area of 270,000 adults. All emergency medical admissions are referred to one of nine teams operating a 1:9 24 hr on-call roster. An average of 20 patients are admitted in each 24 hour period. The 'on-call' system is covered by a 'physician of the day' with a post-call review round. Emergency medical patients are admitted from the Emergency Department to a 59 bedded AMAU, which opened in 2003. The operation of the AMAU has been described elsewhere.[3,10]

Patients on the AMAU are cared for by a cohort of experienced nurses whose expertise and sole professional role is in respect of Acute Medicine patients. Capacity constraints dictate that some patients are admitted directly into a more traditional in-patient ward environment, although their medical care continues to be provided by their admitting consultant and team.

Data collection

For audit purposes we employed an anonymous patient database assembling core information about each clinical episode from elements contained on the patient administration system, the national hospital in-patient enquiry (HIPE) scheme, the patient electronic record, the emergency room and laboratory systems. HIPE is a national database of coded discharge summaries from acute public hospitals in Ireland.[12] Ireland used the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) for both diagnosis and procedure coding from 1990 to 2005 and ICD-10-CM since then.

Data held on the database includes the unique hospital number, admitting consultant, date of birth, gender, area of residence, principal and up to nine additional secondary diagnoses, principal and up to nine additional secondary procedures, and admission and discharge dates. Additional information cross-linked and automatically uploaded to the database includes physiological, haematological and biochemical parameters. Data was related to all emergency general medical patients admitted to SJH in the twelve years between 2002 and 2013. We excluded those patients who were admitted from the emergency department directly into the intensive care unit or the high dependency unit.

Models for prediction of outcome

There are predictor variables that anticipate clinical outcomes following and Emergency Hospital admission; these include Acute Illness Severity,[13,14] Charlson Co-Morbidity Index,[15] Sepsis Status, and Chronic Disabling disease.[16]

1. Acute Illness Severity Score: Derangement of hemodynamic and physiological admission parameters has been utilised to derive an Acute Illness Severity Score that predicts clinical outcomes.[13,14,17,18] From modelling laboratory data collected at the time of hospital admission we developed a predictive algorithm based on serum sodium, potassium, urea, albumin, red cell distribution width, white blood cell count and troponin status. The underlying principle is that deviation beyond the boundaries of 'normal homeostasis' is an estimate of risk, although the relationship is non-linear and differs for each variable. Six groups were originally defined with a 30-day mortality risk increasing in an exponential fashion. The frequency of groups 1 – 6 by episode was 2.7%, 6.3%, 10.4%, 14.0%, 16.6% and 31.5%. The 30-day in-hospital mortality risk calculated by unique patient (last episode if > 1) for the respective groups was 0.13%, 0.12%, 0.63%, 1.42%, 4.73% and 23.8%.

2. The Charlson Co-morbidity index provides an evaluation of Co-morbidity.[15] Co-morbidity is the presence of one or more additional disorders (or diseases) co-occurring with a primary disease or disorder. The Charlson Co-morbidity index predicts the ten-year mortality outcomes for patients who may have a range of Co-morbid conditions, such as heart disease, AIDS, or cancer (a total of 22 conditions). Each condition is assigned a score of 1, 2, 3, or 6, depending on the mortality; scores are then summed into three classifying groups (Groups 0, 1 and 2). Charlson Co-morbidity frequency of groups 0, 1 and 2 by episode was 40.8%, 24.3% and 24.1% and 30-day in-hospital mortality rates, by patient, were 2.9%, 8.8% and 22.0% respectively. The Odds Ratios of a death for Charlson Co-morbidity groups 1 and 2 (compared with group 0) were 3.3 (95% CI: 2.9, 3.6) and 9.3 (95% CI: 8.5, 10.3).

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Table 1. Characteristics of Emergency Medical Admissions (SJH: 2002 - 2013)

Factor	Level	Other Ward	AMAU	p-value
N		40299	26634	
Gender	Male	19884 (49.3%)	12849 (48.2%)	0.005
	Female	20415 (50.7%)	13785 (51.8%)	
Outcome	Alive	38282 (95.0%)	25492 (95.7%)	<0.001
	Died	2017 (5.0%)	1142 (4.3%)	
Age (yr), mean (SD)	<40	9805 (24.3%)	5417 (20.3%)	<0.001
	≥40<60	9891 (24.5%)	6346 (23.8%)	
	≥60<75	9709 (24.1%)	6203 (23.3%)	
	≥75<85	7781 (19.3%)	5655 (21.2%)	
	≥85	3107 (7.7%)	3011 (11.3%)	
LOS (days), mean (SD)		4.0 (1.2, 8.7)	5.0 (2.4, 9.6)	<0.001
Illness Severity Score	1	1217 (3.4%)	768 (3.1%)	<0.001
	2	2975 (8.3%)	1722 (6.9%)	
	3	4822 (13.4%)	3012 (12.0%)	
	4	6307 (17.5%)	4158 (16.6%)	
	5	7427 (20.6%)	4994 (20.0%)	
	6	13256 (36.8%)	10371 (41.4%)	
Manchester Triage	3	26077 (64.7%)	13239 (49.7%)	<0.001
	2	13517 (33.5%)	13052 (49.0%)	
	1	705 (1.7%)	342 (1.3%)	
Disabling Score	0	5413 (13.4%)	2146 (8.1%)	<0.001
	1	10789 (26.8%)	5724 (21.5%)	
	2	11811 (29.3%)	7761 (29.1%)	
	3	7565 (18.8%)	6517 (24.5%)	
	4	4721 (11.7%)	4485 (16.8%)	
Charlson Index	0	19261 (47.8%)	11326 (42.5%)	<0.001
	1	10023 (24.9%)	8226 (30.9%)	
	2	11015 (27.3%)	7081 (26.6%)	

Manchester Triage 30-day in-hospital mortality rates were 3.0%, 6.3%, and 31.2% for Triage Groups 3+, 2 and 1 respectively. Charlson Co-morbidity groups 0, 1 and 2 had 30-day in-hospital mortality rates of 1.9%, 4.0% and 10.2% respectively. Disabling Score 30-day in-hospital mortality rates were 0.8%, 2.4%, 4.0%, 6.3%, and 11.2% respectively.

IQR: Interquartile Range, LOS: Length of Stay.

3. Sepsis (i.e. a septic screen), as evidenced by a request for a blood culture, is predictive of an in-hospital death by day 30. Categorised by no blood culture request,[1] culture request but negative result[2] and culture request with positive result,[3] there were 67.2%, 18.9% and 3.1% of patients by these categories with respective in-hospital mortality rates by patient of 5.5%, 16.2% and 31.9%, by day 30. The Odds Ratios of a death for second and third categories (compared with no blood culture) were 3.4 (95% CI: 3.1, 3.6) and 8.1 (95% CI: 7.2, 9.2). Combining these three predictors gave an AUROC of 0.87 (95% CI: 0.86, 0.88) to predict an in-hospital death by day 30.

4. Disabling disease[16] is frequently present in our emergency admissions; we found disabling disease IDC9/ICD10 discharge codes of 0, 1, 2, 3 or 4 separate systems (e.g. cardiovascular, respiratory, diabetes, renal) in 10.1%, 22.0%, 26.1%, 18.8% and 12.3% of episodes respectively. The respective mortality by patient day 30 were 1.2%, 4.0%, 7.7%, 13.3% and 25.3% . The calculated univariate risk, of an in-hospital death by patient by day 30, gave OR's of 3.5 (95% CI: 2.7, 4.7), 7.2 (95% CI: 5.5, 9.4), 13.3 (95% CI: 10.2, 17.2), and 29.3 (95% CI: 22.5, 38.1) with 1, 2, 3 and 4 disabling codes respectively.

We estimated, based on the foregoing parameters, the risk profile of patients allocated initially to the Ward Group or the AMAU. We entered the parameters into a multiple variable logistic model including Acute Illness Severity,[13,14] Charlson Co-Morbidity Index,[15] Sepsis Status, and Chronic Disabling disease[16] and Major Disease Primary Codings in the Respiratory (MDC4), Cardiovascular

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(MDC5) or Neurological (MDC1) categories. The latter three codes were in terms of frequency 58.9% of primary disease codes with univariate Odds Ratios of (MDC4) 2.34 (95% CI : 2.17, 2.53), (MDC5) 1.18 (95% CI : 1.08, 1.30) and (MDC5) 2.40 (95% CI : 2.10, 2.75).

Statistical methods

Descriptive statistics were calculated for background demographic data, including means/standard deviations (SD), medians/interquartile ranges (IQR), or percentages. Comparisons between categorical variables and mortality were made using chi-square tests. The 30-day in-hospital survival outcome bivariate variable was assessed by fitting a logistic regression model for variables that were univariately predictive. We used margins to estimate and interpret adjusted predictions for sub-groups, while controlling for other variables, using computations of average marginal effects.[24] Margins are statistics calculated from predictions of a previously fitted model at fixed values of some covariates and averaging or otherwise over the remaining covariates.

Adjusted odds ratios (OR) and 95% confidence intervals (CI) or incidence rate ratios (IRR) were calculated for those predictors that significantly entered the model (p<0.10). Statistical significance at P<0.05 was assumed throughout. Stata v.13.1 (Stata Corporation, College Station, Texas) statistical software was used for analysis.

Results

Patient Demographics

A total of 66,933 episodes were recorded in 36,271 unique patients admitted as medical emergencies over the 12 year study period. These episodes represented all emergency medical admissions, including patients admitted directly into the Intensive Care Unit (ICU) or High Dependency Unit (HDU) respectively, who had completed the clinical episode or who had suffered an in-hospital death, with 30 days of admission. Demographics are displayed in table 1.

Initial Ward allocation (Tables 1 and 2; Fig 1)

The initial distribution of patients was 39.8% to the AMAU and 60.2% to other wards.

Patients admitted to the AMAU tended to be higher risk, were older (61.4 (IQR 40.6, 77.6) vs. 55.9 (IQR 35.7, 74.4): p<0.001) and remained in hospital longer (5.0 (IQR 2.4, 9.6) vs. 4.0 (IQR 1.2, 8.7): p<0.001) (Table 1). The AMAU group had an increased Acute Illness Severity Score, Disabling Disease Score, Manchester Triage Category (Categories I and 2) and Charlson Co-morbidity burden (Charlson Index). However, they had less sepsis, as evidenced from blood culture requests and more Respiratory and Cardiovascular primary (MDC) diagnoses.

Table 2. Table II: Multi-variable logistic regression model for a 30-day in-hospital death – Risk Profile by Ward or AMAU initial allocation.

Parameter	Wards	AMAU	p <
Illness Severity	3.48 (3.18, 3.82)	4.35 (3.71, 5.10)	0.02
Charlson Index	1.61 (1.50, 1.74)	1.57 (1.43, 1.73)	0.67
Disabling Score	1.00 (0.95, 1.05)	1.48 (1.38, 1.60)	0.001
Sepsis Status	2.57 (2.37, 2.78)	2.04 (1.82, 2.27)	0.001
Respiratory	2.08 (1.83, 2.38)	1.84 (1.56, 2.17)	0.25
Cardiovascular	2.25 (1.92, 2.64)	1.48 (1.22, 1.81)	0.001
Neurological	2.72 (2.28, 3.24)	1.85 (1.48, 2.31)	0.008

The multi-variate model assessed the risk of 30-day in-hospital death by allocation to AMAU or Ward. The data were adjusted for other risk predictors. The model parameters were stored; post-estimation intramodel and cross-model hypotheses can then be tested. The AUROC to predict an in-hospital death within 30 days for the Ward Group was 0.87 (95% CI 0.87, 0.88) and for the AMAU Group 0.87 (95% CI 0.86, 0.88).

Using the validated, multi-variable risk model[13] The AUROC, from the multi-variable model, to predict an in-hospital death within 30 days for the Ward Group was 0.87 (95% CI 0.87, 0.88) and for the AMAU Group 0.87 (95% CI 0.86, 0.88). These data suggest that it would have been a reasonable expectation for similar hospital mortality outcomes between the groups (figure 1).

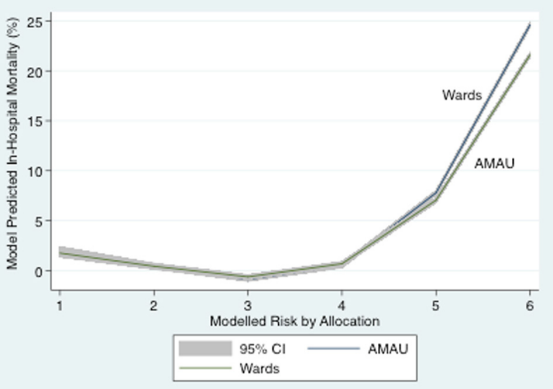

Figure 1. Predicted 30-day Hospital Mortality (%) by initial allocation to Wards or AMAU. The Multi-variable model was computed based Acute Illness Severity (13, 14), Charlson Co-Morbidity Index (15), Sepsis Status, and Chronic Disabling disease (16) and Major Disease Primary Codings in the Respiratory (MDC4), Cardiovascular (MDC5) or Neurological (MDC1) (see text). The Risk profile was comparable between the groups.

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Table 3. Logistic multi-variable regression model to predict in-hospital death

Predictor	Odds Ratio	[95% Intervals]		z	P>z
Illness Severity					
2	0.78	0.14	4.27	-0.29	0.77
3	3.36	0.80	14.2	1.65	0.1
4	6.44	1.56	26.7	2.57	0.01
5	17.2	4.20	70.8	3.95	0.001
6	72.2	17.6	296	5.94	0.001
Age Group					
40 -	1.54	1.19	2.00	3.28	0.001
60 -	1.28	1.00	1.65	1.89	0.06
75 -	1.63	1.26	2.11	3.74	0.001
85+	2.31	1.77	3.00	6.24	0.001
Charlson Index					
1	1.58	1.38	1.80	6.72	0.001
2	2.61	2.32	2.94	15.6	0.001
Disabling Score					
1	1.26	0.91	1.75	1.40	0.16
2	1.21	0.87	1.66	1.14	0.26
3	1.18	0.85	1.63	1.00	0.32
4+	1.71	1.23	2.38	3.20	0.001
Sepsis Group					
2	2.78	2.53	3.06	21.2	0.001
3	5.25	4.51	6.11	21.3	0.001
MDC Group					
Respiratory	1.94	1.74	2.15	12.3	0.001
Cardiovascular	1.87	1.65	2.12	9.80	0.001
Neurology	2.21	1.92	2.55	11.1	0.001
AMAU vs Ward	0.67	0.61	0.73	-8.86	0.001

Each categorical predictor is evaluated in terms of the base risk (lowest or highest in group) as appropriate. Illness Severity Group vs Group 1. Age base group < 40 yr. Charlson Co-Morbidity Index Groups 1 and 2 vs Group 0. Chronic Disabling Score vs no Disabling Disease (Score 0). Sepsis – comparison vs. no blood culture.

Mortality related to AMAU or Ward admission

The overall 30-day in-hospital mortality by episode was 4.7% (95% CI 4.6% - 4.9%); between 2002 and 2013 it fell from 5.5% to 3.9% representing a 28% Relative Risk Reduction over the period with a calculated Numbers to Treat of 65. This view of mortality, calculated by episodes, needs to be placed in the context of a 12 yr time series where 62.5% of the patients were admitted at least once and approximately 3% > 30 times each. An alternative determination is to calculate the overall mortality by unique patient (last admission if > 1); this yields a global estimate of 30-day inhospital mortality risk of 8.7% (95% CI 8.4% - 9.0%); between 2002 and 2013 this mortality estimate was reduced from 11.8% to 5.0% representing a 58% Relative Risk Reduction over the period with a calculated Numbers to Treat of 14.6.

The mortality, by unique patient, in those allocated to a ward between 2002 and 2013 was 9.6% (95% CI 9.2% - 10.0%); this contrasted with those initially allocated to the AMAU, where the figure was 7.5% (95% CI 7.1% - 7.9%). One way analysis of variance indicated that this mortality difference, for patients with calculated similar risk profiles, was highly significant ($p<0.001$). The univariate OR of an in-hospital death by day 30 for a patient initially allocated to the AMAU, compared with an initial Ward allocation, was 0.76 (95% CI : 0.71, 0.82); this reduction was highly significant ($p<0.001$).

Mortality related to AMAU or Ward admission; multi-variable adjustment (Table 3: Fig 2)

The full model, as previously described, to predict a 30-day in-hospital death had an Area Under

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Receiver Operating Characteristic (AUROC) of 0.88 (95% CI 0.88, 0.89). The fully adjusted multivariate estimate of the OR of an in-hospital death by day 30 for a patient initially allocated to the AMAU, compared with an initial Ward allocation, was 0.67 (95% CI : 0.62, 0.73); this was highly significant ($p<0.001$) (figure 2).

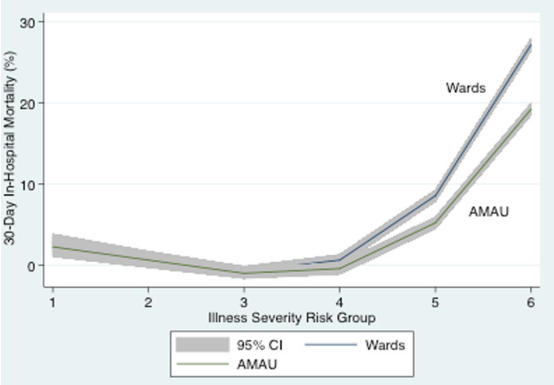

Figure 2. 30-day Hospital Mortality (%) as a function of Acute Illness Severity (admission laboratory score). Mortality increased with score, but was significantly lower for patients admitted to the AMAU, despite equivalent initial risk profile (see text).

Discussion

The acute medical take is the point of presentation of acutely ill and distressed patients to the hospital care system. Historically the model of care afforded to these patients was a benevolent offering. In such an approach one could argue that expectations of both the care provider and recipient are low. Paradoxically as medicine has become more specialised we have seen the development of a coherent evidence base for treatment of organ specific illnesses such as stroke, heart disease and chronic obstructive airways disease.[21-23] Efforts are made by institutions to implement these changes and it can be seen as a failure of standards if patients are not able to benefit from these structured systems that have been shown to optimise the patient journey and enhance outcomes.

The development of acute medical units in the UK was a response to the often fragmented system of care for those patients admitted on acute unselected medical take.[24] The results outlined in this paper reinforces the case that structured acute medical care is associated with improved outcomes for those patients admitted under acute unselected take. Whilst our study represents the experience of a single centre it represents a 12 year time frame encompassing over 36,000 patients. A distinct survival advantage, in the order of 33% lower mortality risk, was derived by those patients cared for within the matrix of an acute medical unit. The absolute risk reduction was 0.7%. This differential is real but probably too small to identify in real time clinical practice. On this basis we would argue that a system of continuous prospective audit designed to identify variations in outcomes would be worthwhile.

A variety of factors may influence ward allocation, including Illness Acuity, bed availability and other factors (pressures) such as Health Sector Targets (Emergency Wait times). Our data suggest that the benefit of structured care exists across all illness severity and disabling illness categories. In this regard it is worth noting that being admitted to the AMU did not confer any advantage in terms of access to specialist care pathways such as palliative services, nor were there any differences in access to AMU admission across days of the week or time of the day.

Those charged with designing health care systems should plan their services to ensure that all patients, irrespective of age or illness severity, have access to systems of care that enhance their possibility of a good outcome. This encompasses a whole system approach that ensures appropriate patient flow with the availability of acute medical unit beds, matching the time of presentation of new patients. Whilst many of the key elements of an acute medical unit are generic and well described (10, 24) it is likely that the development of this exciting field shall remain iterative with recognition of the ageing profile of our population[25] and a commitment to treating patients in the right place at the right time with appropriate leveraging of the potential of ambulatory care.[26,27] Our view is that improvements in acute medical care will be best achieved in dedicated units which are developed and scaled to meet the need of the catchment population. These units must be staffed by appropriate numbers of medical, nursing and ancillary personnel who are focused on the care of acute medical patients in an environment with a culture of continuous quality improvement.

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Conflict of interest

Nothing to declare

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