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Physical activity and annual medical outlay in U.S. colorectal, breast and prostate cancer survivors

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ABSTRACT

Multiple chronic conditions in cancer survivors are highly prevalent and may increase health care costs for both patients and the health care system. Studies of cancer survivors reveal positive effects of physical activity (PA) on reducing risk of cancer recurrence, other chronic conditions, and secondary cancer. Few nationally representative studies have examined how physical activity levels have affected survivors' annual economic burden in the United States.

Leisure-time physical activity data from the National Health Interview Survey was linked to health care expenditure data from the Medical Expenditure Panel Survey data (2008–2012). We calculated per-person annual total medical expenditures for identified colorectal, breast, and prostate cancer survivors. We conducted multivariable analyses controlled for survival years and other sociodemographic variables. Generalized linear models were performed to measure correlation between medical expenditure and PA level using STATA 14. All analyses considered the complex survey design and were conducted in 2017.

Of 1015 cancer survivors sampled, 30% (n = 305) adhered to physical activity recommendation, while the other 70% (n = 710) did not. Multivariable-adjusted expenditure in adherence group was $9108.8 (95% CI 7410.9–10,806.7) versus 12,899.1 (95% CI 11,450.2–14,348) in non-adherence group. Stratified analyses revealed cancer survivors who adhered to their PA recommendation saved $4686.1 (1–5 years' survival time) and $2874.5 (11 or more years' survival time) on average for total health care expenditure, respectively.

Analyses of the national representative sample revealed that the economic burden of survivors from the three most prevalent cancers is substantial. Increasing survivor's PA to guidelines may reduce U.S. health care expenditure.

1. Introduction

Cancer survivors, both those undergoing active treatment and those who have lived with the diagnosis in the long term, are a steadily-growing segment of the US population (Rim et al., 2016). There are approximately 15.5 million cancer survivors in the United States, with the number projected to exceed 20 million by 2026 (Miller et al., 2016). The economic burden of cancer survivorship in the United States is substantial (Guy et al., 2015). Every seven in ten survivors suffer from multiple chronic conditions (MCCs), such as cardiovascular disease, diabetes, and obesity (Edwards et al., 2014). These conditions (Rim et al., 2016; Giovannucci et al., 2010) can complicate health care delivery (i.e., cancer treatment) and create practical concerns about survivorship care (Rim et al., 2016; Ward et al., 2014). The presence of MCCs may also increase health care costs for patients and, more broadly, for the health care system (Rim et al., 2016; Edwards et al., 2014).

The MCCs and competing causes of death are believed to stem from cancer treatment, genetic predisposition, and/or common lifestyle factors (Demark-Wahnefried and Jones, 2008). Healthy lifestyle behaviors like physical activity (PA) hold promise for reducing the risk of comorbidities, such as cardiovascular disease (Hewitt et al., 2003; Oeffinger and Hudson, 2004), diabetes (Earle et al., 2003), and obesity (Chelbowski et al., 2002), and could prevent cancer recurrence and cancer-specific mortality (Carmack Taylor et al., 2006; Parry et al., 2011; Blackburn and Wang, 2007; Demark-Wahnefried et al., 2005), and improve quality of life (Irwin et al., 2008; McNeely et al., 2006). Most of the evidence supporting the potential benefits of physical

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activity in cancer survivors comes from people diagnosed with breast, prostate, or colorectal cancer (Schmid and Leitzmann, 2014), the three most prevalent types of cancers. These cancers, to some degree, appear to have similar comorbidities associated with physical activity levels. For instance, in the United States, patients with breast and prostate cancer had a prevalence of 30–32% for comorbidity, and colorectal cancer had a prevalence of 41% (Edwards et al., 2014).

Estimating the economic burden of cancer among patients with comorbidities has become increasingly important for physicians, employers, policy makers, health care systems, and for society at large. To our best knowledge, few nationally-representative studies have examined how physical activity levels affect survivors' annual economic burden in the United States, particularly among survivors of prostate, colorectal, and breast cancers. Given the fact that more people are surviving to older ages with MCCs, it is critical to explore how public health prevention strategies, such as promoting physical activity, might affect survivors' medical costs, in the context of recent transformations that embed prevention in the broader health care delivery system. Such research can provide decision makers in both public and private sectors with evidence in the hope of implementing fundamental changes, thus altering the way in which we deliver health care.

To date, the majority of studies with detailed information on economic burden (i.e., from surveillance, epidemiology, and end results (SEER)-Medicare databases) were conducted exclusively among Medicare beneficiaries aged 65 years and older (Mariotto et al., 2011; Yabroff et al., 2011; Yabroff et al., 2008). The Medical Expenditure Panel Survey (MEPS), conducted by the Agency for Healthcare Research and Quality (AHRQ), is a nationally representative survey of the civilian non-institutionalized population of all ages in the US. MEPS is also the only national data source that measures Americans' use of, and payment for, medical care and health insurance. It provides comprehensive information about all types of health insurance, in cancer survivors of all ages. More importantly, MEPS contains socioeconomic variables, including education and income level, which are highly correlated to individual health behavior patterns but not available in clinically and insurance-based datasets like SEER-Medicare.

The purpose of this study is three fold: (1) to examine the prevalence of MCCs and physical activity adherence; (2) to examine the association between MCCs and annual health care costs; and (3) to examine how physical activity adherence affects an individual's annual total economic burden, among a nationally representative sample of prostate, colorectal, and breast cancer survivors in the United States. In particular, we examined the independent effects of physical activity adherence on total health care expenditures, and stratified by lengths of survival.

2. Methods

2.1. Study design and data source

We measured the association between annual health care expenditures and individual adherence to physical activity recommendations among cancer patients, by pooling cross-sectional data from the 2008–2012 MEPS (Cohen et al., 2009) and its corresponding National Health Interview Survey (NHIS) data (National Center for Health Statistics, 2017). Since MEPS respondents are from a subsample of NHIS with a shared unique identifier, we were able to link two datasets using the linkage files provided by the National Center for Health Statistics Data Center. The linked NHIS/MEPS data (Quality AfHRa, 2017) allowed us to access multiple variables for the same respondents from both data sources. The MEPS is an ongoing annual survey maintained by the Agency for Healthcare Research and Quality. It collects detailed information on demographics, socioeconomic status, health conditions, health service utilization and costs from a nationally representative sample of non-institutionalized civilian Americans, as well as their medical providers and employers. The linkage to NHIS further provided data on respondents' minutes of moderate and vigorous physical activities. This study included adult patients aged 18 and older, who were diagnosed with any of the three most prevalent types of cancers: prostate, colorectal, and breast cancer. Our original sample size was 1092, and listwise deletion resulted in a final analytical sample of 1015 cancer survivors.

2.2. Measures

2.2.1. Health care expenditures

Our outcome of interests was annual total health care expenditure derived from MEPS. Total health care expenditures are the sum of all direct actual third-party (private insurance, Medicare, Medicaid, Veterans Administration, other federal sources) payments made to the providers for various types of services rendered, plus the out-of-pocket spending by the individual or family during the calendar year. These services included inpatient and outpatient care, emergency department visits, prescriptions, home health care, durable medical equipment, dental care, and eye care.

2.2.2. Physical activity level

The primary independent variable indicated whether respondents adhere to physical activity recommendations. In the NHIS, participants were asked about weekly frequency and average duration of leisure-time physical activities of at least 10 min duration including 1) vigorous-intensity activities (i.e., heavy sweating or large increases in breathing or heart rate) and 2) moderate-intensity activities (i.e., light sweating or slight to moderate increases in breathing or heart rate). We first calculated total minutes per week of vigorous or moderate activity, then categorized participants into two levels of physical activity using the Centers for Disease Control and Prevention (CDC) guidelines (US Department of Health and Human Services, 2008): 1) adherence to physical activity guidelines (total minutes equal to 150 or more of moderate-intensity physical activity per week or total minutes equal to 75 min or more of vigorous-intensity physical activity per week); 2) non-adherence including insufficiently active, or inactive.

2.2.3. Covariates

We also controlled for demographic characteristics, socioeconomic status, and health conditions in multivariable analyses, including age in year, race/ethnicity (Hispanic, non-Hispanic white, non-Hispanic Black, and Non-Hispanic other), education attainment (less than high school, high school, and college and above), income level ($\geq$125% vs. $<$ 125% Federal Poverty Level), insurance status (uninsured vs. insured), cancer type (breast cancer, colon cancer, and prostate cancer), chronic conditions and cancer survival time (0–5, 6–10, 11 years and above). If one patient was diagnosed with two or more types of cancer, we used the most recent one to define survival time. The respondents were asked whether they had been told by a doctor or other health professional that they had any of the following common chronic conditions, including hypertension, cardiovascular disease, stroke, diabetes, emphysema, asthma, and arthritis. We also defined overweight or obesity with their self-reported body mass index (BMI) being $>$ 25 kg/m^2 (National Heart L, and Blood Institute, 1998). All the respondents were further categorized into three groups by their number of conditions, including 0, 1, 2 and above. For the purpose of the analyses, we categorized numbers of chronic conditions into three groups: none, one, and two and above.

2.3. Statistical analysis

Data was obtained in 2017. We first performed univariate analyses to describe the distributions of annual health care expenditure, demographic characteristics, socioeconomic status, and health conditions by physical activity adherence. We used a Pearson χ^2 test to examine whether expenditure and other covariates varied significantly between

Table 1
Descriptive statistics of demographic, socioeconomic, and health characteristics by adherence to physical activity recommendation, MEPS 2008–2012.

	Physical activity adherence (N = 305)		Physical activity non-adherence (N = 710)		p-Value
	Estimate	95% CI	Estimate	95% CI	
Annual health care expenditure (dollar)	9172.3	[7266.1, 11,078.6]	12,907.8	[11,380.2, 14,435.4]	**0.003**
Age (years)	64.9	[63.0, 66.7]	69.8	[68.7, 71.0]	< **0.001**
Race/ethnicity					
Non-Hispanic White	85.4	[81.9, 88.3]	79.9	[76.9, 82.6]	**0.001**
Non-Hispanic Black	7.0	[4.9, 9.8]	12.5	[10.6, 14.7]	
Hispanic	4.1	[2.7, 6.1]	5.6	[4.2, 7.4]	
Non-Hispanic Other	3.6	[2.0, 6.4]	2.0	[1.2, 3.4]	
Education attainment					
Less than high school	8.6	[5.6, 12.8]	21.4	[18.3, 24.9]	< **0.001**
High school	22.8	[18.0, 28.4]	36.6	[33.1, 40.2]	
College and above	68.7	[63.0, 73.9]	42.0	[37.7, 46.5]	
Income level					
Less than 125% FPL	9.7	[7.0, 13.5]	20.0	[17.4, 23.0]	< **0.001**
125% FPL and above	90.3	[86.5, 93.1]	80.0	[77.0, 82.6]	
Insurance status					
Uninsured	2.7	[1.2, 6.1]	1.6	[1.1, 2.4]	0.284
Insured	97.3	[93.9, 98.8]	98.4	[97.6, 98.9]	
Number of chronic conditions					
0	15.8	[12.2, 20.3]	9.0	[6.8, 11.9]	**0.001**
1	25.8	[20.1, 32.4]	20.0	[16.7, 23.7]	
2–	58.4	[52.5, 64.0]	71.0	[66.8, 74.8]	
Colon cancer	9.9	[6.7, 14.5]	20.2	[16.8, 24.0]	< **0.001**
Breast cancer	47.0	[40.7, 53.5]	50.3	[46.1, 54.4]	0.425
Prostate cancer	43.9	[37.6, 50.3]	31.3	[27.3, 35.6]	< **0.001**
Survival time (years)					
0–5	50.9	[45.1, 56.6]	52.1	[47.4, 56.7]	0.067
6–10	23.6	[18.6, 29.5]	17.3	[14.3, 20.8]	
11–	25.5	[20.1, 31.8]	30.6	[26.4, 35.2]	

FPL: Federal Poverty Level.
Boldface indicates statistical significance ($p < 0.05$).

groups. We further employed multivariable generalized linear models with a log link and gamma distribution to model the relationship between annual expenditure and physical activity. Lastly, we conducted stratified analyses to explore whether the impact of physical activity on expenditure was consistent across the extent of survival. Since MEPS adopts a multi-stage design with weights to reflect nonresponse rate, we conducted all the analyses adjusted for this complex survey design and weight using svyset command (Machlin et al., 2005) in Stata version 14.0 MP (StataCorp, College Station, TX) to produce national estimates. A p-value < 0.05 was considered statistically significant.

3. Results

Table 1 presents annual health care expenditure, demographic, socioeconomic, and health characteristics of respondents by adherence to physical activity recommendations. Of 1015 cancer survivors in our sample, 30% (n = 305) adhered to physical activity recommendations, while the rest 70% (n = 710) did not. On average, a cancer survivor who adhered to the recommendation spent $9172 (95% Confidence Interval [CI]: 7266.1–11,078.6) per year on health care, which was significantly lower (p = 0.003) than non-adherers ($12,907.8; 95% CI: 11,380.2–14,435.4). In the adherence group, 9.9%, 47.0% and 43.9% of survivors were diagnosed with colorectal, breast, and prostate cancer, respectively, compared to 20.2% ($p < 0.001$), 50.3% (p = 0.425), and 31.3% ($p < 0.001$) in the non-adherence group. There was no significant difference in the lengths of survival between two groups.

Participants in the adherence group tended to be younger (64.9 vs. 69.8 years old, $p < 0.001$) and non-Hispanic black (7.0% vs. 12.5%, p = 0.001) than those from the non-adherence group. Survivors who did not follow physical activity recommendations were more likely to have less than high school education (21.4% vs. 8.6%, $p < 0.001$) and an annual income below 125% Federal Poverty Level (20% vs. 9.7%, $p < 0.001$). The adherence group also had a lower number of chronic conditions than the non-adherence group. For example, 15.8% of patients with adherence to the recommendation reported no chronic conditions diagnosed by health care professionals, while the percentage in the non-adherence group was only 9.0% (p = 0.001).

In the multivariable regression model controlling for demographic characteristics, socioeconomic status, health condition, the total annual health care expenditure all remained negatively associated with survivors' adherence to physical activity recommendations (Table 2). Among all cancer survivors, multivariable-adjusted annual expenditures were significantly different (p = 0.009) between the adherence group $9108.8 (95% CI 7410.9–10,806.7) and the non-adherence group 12,899.1 (95% CI 11,450.2–14,348). Survivors who were uninsured and had longer cancer survival lengths spent less on health care than those with insurance, and those who had been diagnosed in recent years, respectively. Having more than two chronic conditions was significantly associated with higher expenditure among survivors.

Stratified analyses further revealed that the impacts of physical activity in decreasing health care expenditure varied across lengths of survival in patients with cancer (Table 3). On average, the cancer survivors who adhere to physical activity recommendations spent $4686.1 (1–5 years survival time, p = 0.002) and $2874.5 (11 years and longer survival time, p = 0.037) less for total annual health care expenditure, respectively. Such expenditure savings were not found in patients with 6–10 years of survival time.

4. Discussion

In the current study, we linked the 2008–2012 MEPS database, a nationally representative survey of the US non-institutionalized civilian population, to the National Health Interview Survey at the individual level. The findings show that for survivors of colorectal, prostate and breast cancers, adherence to physical activity recommendations were

Table 2
Multivariable-adjusted relationship between annual health care expenditure and adherence to physical activity recommendation, MEPS 2008–2012.

	Coefficient	95% CI
Physical activity adherence	−0.276**	[−0.481, −0.072]
Age (years)	−0.003	[−0.011, 0.005]
Race/ethnicity		
Non-Hispanic White	Ref	Ref
Non-Hispanic Black	0.109	[−0.146, 0.364]
Hispanic	0.035	[−0.232, 0.301]
Non-Hispanic Other	0.555	[−0.002, 1.111]
Education attainment		
Less than high school	Ref	Ref
High school	0.036	[−0.224, 0.296]
College and above	0.084	[−0.166, 0.334]
Income level		
125% FPL and above	Ref	Ref
Less than 125% FPL	0.168	[−0.063, 0.398]
Insurance status		
Insured	Ref	Ref
Uninsured	−1.073**	[−1.791, −0.355]
Number of chronic conditions		
0	Ref	Ref
1	0.110	[−0.374, 0.593]
2 and more	0.461*	[0.016, 0.905]
Cancer type		
Breast cancer	−0.249	[−0.768, 0.270]
Colon cancer	−0.100	[−0.569, 0.370]
Prostate cancer	−0.435	[−0.954, 0.084]
Length of survival (years)		
0–5	Ref	Ref
6–10	−0.341**	[−0.564, −0.118]
11 and above	−0.426***	[−0.673, −0.180]

FPL: Federal Poverty Level.
* < 0.05.
** < 0.01.
*** < 0.001.

Table 3
Total health care expenditure ($) and expenditure saved by physical activity adherence ($).

	Total annual health care expenditure ($)		
	Physical activity adherence	Physical activity non-adherence	Health care expenditure saved by physical activity adherence ($)
Cancer survival time			
1–5 years	10,811.4 [9866.6, 11,756.1]	15,470.2 [13,060.7, 17,879.7]	4686.1 [1504.9, 7867.3]**
6–10 years	7387.5 [6553.6, 8221.3]	10,615.8 [9042.2, 12,189.5]	375.3 [−2364.1, 3114.8]
11 years and longer	7557.5 [6732.3, 8382.7]	9846.2 [8959.9, 10,732.6]	2874.5 [398.1, 5350.9]*

95% Confidence Interval in parentheses.
*$p < 0.05$, **$p < 0.01$. Models adjusted for age, race/ethnicity, education attainment, income level, insurance status, cancer type and number of chronic conditions.

associated with decreased total annual health care expenditure, independent of demographic characteristics, socioeconomic status and other health conditions. We also found that the impacts of adherence to physical activity, with the presence of multiple chronic conditions, on annual health care expenditure vary according to length of the survival time. The current study adds to the literature that the considerable financial burden for cancer survivors associated with inadequate levels of physical activity in the United States could potentially be reduced by increasing their physical activity to levels consistent with current guidelines (US Department of Health and Human Services, 2008) and Healthy People 2020 objectives (U.S. Department of Health and Human Services, n.d.).

It is well known that multiple chronic conditions are common among cancer survivors (Rim et al., 2016). Survivors with comorbidities incurred significantly higher total medical costs and out-of-pocket expenses compared to cancer survivors without additional comorbidities (Rim et al., 2016). Thus, the economic impact of chronic conditions on cancer survivorship is substantial (Rim et al., 2016; Guy et al., 2013). Although evidence (Booth et al., 2012; Schmitz et al., 2010) shows that lack of exercise increases the risk of multiple chronic diseases and certain cancers, our data of survivors of three most common cancers show that approximately one third of the survivors adhered to physical activity recommendations. Our adherence rate was similar to the rate of physical activity adherence from a National Cancer Institute 2015 national survey (National Cancer Institute, 2017), where 38.3% of cancer survivors aged 18 years and older reported no physical activity in their leisure time. It is worth noting that ethnic disparities in adherence were observed. For example, of all racial and ethnic groups examined in this study, Hispanic and Black cancer survivors and survivors of lower income and educational levels were more likely to be non-adherent to physical activity guidelines than white patients. Our statistics highlight the need to incorporate culturally competent interventions aimed at increasing exercise for survivors of diverse racial or ethnic backgrounds. When educating breast cancer survivors, programs should address sociocultural factors that may hinder or facilitate engagement in exercise.

To our knowledge, this is the first study that quantifies impacts of physical activity adherence on medical expenditures in adult survivors of three most common types of cancers at the national level in the United States. By linking two groups of nationally representative survey data, this study enables important comparisons of the economic burden between subgroups. Specifically, on average, survivors who adhere to physical activity recommendations spend significantly lower ($9108.80) than non-adherers ($12,899.10) on health care per year. Our findings are consistent with a recent study (Valero-Elizondo et al., 2016) on medical cost savings as a result of physical activity among patients who had cardiovascular disease. In particular, we found that regular exercisers saved average health care costs of over $4500 (survival length of 1–5 years) and over $2800 (survival length of 11 years and longer) per year than those who did not meet exercise guidelines. In a recent study, Ding et al. (2016) concluded that inactivity costs the United States almost $28 billion annually in medical expenses and lost productivity. Our findings are encouraging and reflect the recommendations from the Exercise Is Medicine (EIM) Initiative (Lobelo et al., 2014), JAMA (Berra et al., 2015), and Circulation (Kraus et al., 2015) to translate physical activity research into health care practice. However, cost effectiveness cannot be limited to calculations of health care costs alone. The value of regular physical activity far exceeds the monetized benefits. Increases in physical activity behavior improve physical and mental functioning, quality of life, and other non-health dimensions of wellbeing (i.e., the impact of exercise on income and family earnings, mood states, etc.).

The results of an active lifestyle's insignificant influence on medical spending from the 6–10 year survival group seem puzzling. Two reasons may help to explain this surprising finding, including relaxation of vigilance and delayed side effects from treatment. Five-year survival, often considered as a critical milestone, demands persistent vigilance and surveillance from cancer patients. The relaxation of this vigilance after the first five years possibly results in the development and expression of comorbidities that are independent of physical activity, thus increasing health care expenditure. However, in a long run exemplified by over 10-year survival, patients who comply with recommendations on physical activities would still benefit from health care spending reduction associated with decreased age-related inactivity risks. In addition, cancer-specific and treatment-induced side effects, including cardiovascular toxicity (Agrawal, 2014; Albini et al., 2010), cognitive impairments (Falleti et al., 2005; Vardy, 2009), treatment-induced bone

loss (CTIBL) (Edwards et al., 2011), fatigue (Silva et al., 2015), pain (Silva et al., 2015), and others, do not always arise immediately after cancer treatment. It is critical to raise awareness among the medical community about the importance of managing those long-term treatment-related side effects or complications. As breast cancer becomes a chronic condition, health care practitioners must recognize and manage the long-term sequelae of the constellation of therapeutic modalities. Long-term survivors face many challenges as they transition from active treatment to living the rest of their lives. They represent a unique and extremely complex group of patients. Not only do they have the challenge of dealing with multiple long-term side effects of treatment protocols, but many are also forced to address the preexisting comorbidities of their therapies, which often include multiple other issues (Bodai and Tuso, 2015). Although most survivors will not die of the three most common types of cancer presented in this study, their multiple chronic conditions (e.g., obesity, hypertension, hyperlipidemia, and diabetes mellitus) will most certainly increase health care expenditures and affect disease-free survival as well as, ultimately, overall survival and quality of life.

This study has several important strengths. First, MEPS is a nationally representative household survey of health care utilization and expenditures. It is one of the most detailed data sources available for estimating medical expenditures and out-of-pocket costs. The current linked data from the NHIS and MEPS include a large, nationally representative sample, allowing for broad generalizability of findings to non-institutionalized U.S. adults. Second, the NHIS and the MEPS contained relevant variables that permitted us to include many covariates and provided data that could be used to conduct stratified subgroup analyses. As demonstrated by our findings, the unique subgroup economic analyses on length of survival may shed light on what specific survivor groups' primary care providers need to pay special attention to when implementing long-term survivorship care for cancer survivors, including continuing testing for cancer, managing side effects, encouraging healthy behaviors, and coordinating medical care. Third, the physical activity measure categorized individuals into levels consistent with current physical activity guidelines (Miller et al., 2016). Last but not least, as comprehensive, population-based data on cancer patients and comorbidities is limited, the current study can provide us with an initial understanding of the timing and impact of the onset of chronic conditions and physical activity for survivors.

Although MEPS is one of the most detailed and nationally representative data sources available for estimating the economic burden of cancer survivorship, there are a number of limitations in this study. First, this study relied on household-reported data, including the identification of cancer survivors, which introduces potential reporting biases. However, such bias may be limited given the general agreement between household reports and physician-reported conditions (Guy et al., 2013). Second, we were unable to examine the burden by cancer site (i.e., analyze colorectal, prostate, and breast cancer survivors separately) given the inadequate sample size. Lastly, the cross-sectional study design would not allow us to examine the causal relationship between physical activity and health care expenditure. Future research is warranted to investigate this by using longitudinal data collected from cohort studies.

Our study revealed that the economic burden of survivors is substantial. Increasing survivors' physical activity in accordance with guidelines may reduce U.S. health care expenditure. However, only a limited number of cancer survivors meet the guidelines. This suggests a more integrated health care delivery model that incorporates and emphasizes the role of public health professionals or primary care providers to promote an active lifestyle and achieve health care spending reduction within the system.

Conflict of interest statement

All authors declare that he/she has no conflict of interest of this study.

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