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Prevalence, and associated risk factors, of self-reported diabetes mellitus in a sample of adult urban population in Greece: MEDICAL Exit Poll Research in Salamis (MEDICAL EXPRESS 2002)

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Abstract

Background: The continuous monitoring and future prediction of the growing epidemic of diabetes mellitus worldwide presuppose consistent information about the extent of the problem. The aim of this study was to determine the prevalence of diagnosed diabetes and to identify associated risk factors in a sample of adult urban Greek population.

Methods: A cross-sectional population-based survey was conducted in municipality of Salamis, Greece, during an election day (2002). The study sample consisted of 2805 participants, aged 20–94 years. Data were collected using a standardized short questionnaire that was completed by a face-to-face interview. Multiple regression analyses were performed to evaluate the association of diabetes with potential risk factors.

Results: The overall prevalence of diagnosed diabetes was 8.7% (95% CI 7.7–9.8%). After age adjustment for the current adult population (2001 census) of Greece, the projection prevalence was calculated to 8.2%. Multivariate logistic regression analysis identified as independent risk factors: increasing age (odds ratio, OR = 1.07, 95% CI 1.06–1.08), male sex (OR = 1.43, 95% CI 1.04–1.95), overweight and obesity (OR = 1.97, 95% CI 1.29–3.01 and OR = 3.76, 95% CI 2.41–5.86, respectively), family history of diabetes (OR = 6.91, 95% CI 5.11–9.34), hypertension (OR = 2.19, 95% CI 1.60–2.99) and, among women, lower educational level (OR = 2.62, 95% CI 1.22–5.63). The prevalence of overweight and obesity, based on self-reported BMI, were 44.2% and 18.4%, respectively. Moreover, the odds for diabetes in obese subjects with family history were 25-fold higher than those with normal weight and without family history of diabetes, while the odds in overweight subjects with family history of diabetes were 15-fold higher.

Conclusions: Our findings indicated that the prevalence of diabetes is high in Greek population. It is suggested that the main modifiable contributing factor is obesity, whose effect is extremely increased upon positive heredity presence.

Background

Diabetes Mellitus (DM) is a major public health problem, causing significant morbidity and mortality. The prevalence of DM has increased markedly in recent decades and varies widely between populations [1-3], reflecting differences in both environmental influences and genetic susceptibility [4]. Currently, it is estimated that about 150 million people in the world have diabetes and, this number, is expected to double – to about 300 million – by the year 2025 [5].

Despite awareness of the growing problem of diabetes, worldwide [5,6], few developed countries provide consistent data regarding the prevalence and incidence of diabetes [7-9].

In Greece, since the publication of Katsilambros et al [10] in the early 1990s, no study has been conducted concerning urban Greek population. They reported an increasing prevalence of known DM, of the population as a whole, from 2.4 to 3.1% since 1974.

In view of limited current data regarding the prevalence of known DM in Greece we conducted a cross-sectional study in an urban population from the greater Athens area. The study was also undertaken with aim to evaluate the associations between several factors with the prevalence of DM and to compare this information with previous reports.

Methods

Study design and data collection

The study was carried out in the Municipality of Salamis located in the island with the same name, which belongs to the greater region of Attica, at a relatively small distance from Athens.

The survey was conducted during municipal elections, on 13th October 2002. Ten specifically trained health professional interviewers performed face-to-face interviews, using a standardized, previously validated (by our institution) questionnaire. The questionnaire was anonymous, and took no more than 3 minutes to complete. All Salamis poll stations, 8 in total, were included in the sampling and individuals were selected at random on attendance. The participants were unaware about the content of questionnaire, in order to minimize affecting reported data by selection bias.

The following information was collected from the participants concerning: year of birth, sex, origin (born or not in Salamis), self reported height and weight, educational level (low or ≤ 9 years of school, moderate or 10–14 years of school and higher or >14 years of school), current or

former smoking, as well as medical history of diabetes and hypertension, as evaluated by the interviewer.

Individuals were considered to have diabetes if they reported a previous medical diagnosis of diabetes. They were also asked if they were using insulin or oral antidiabetic agents. Presence of diabetes was confirmed by question regarding the year (or age) at diagnosis of diabetes. Family history of diabetes (in parents or/and siblings) was recorded.

The subjects were considered as hypertensive if they had been previously diagnosed and were also asked if they were using antihypertensive drugs. We also retrieved information regarding history of myocardial infarction and known hypercholesterolemia.

The smoking habit was categorized as: smokers if they were currently smoking ≥ 5 cigarettes per day, non-smokers if never smoked and former smokers if they had smoked previously but were nonsmokers at least one year before the interview.

We used data on self reported weight and height to calculate BMI. Participants were classified as overweight if their BMI was 25–29.99 kg/m² and as obese if BMI was ≥ 30 kg/m².

The study protocol was approved by the Scientific and Ethical Committee of the "Saint Panteleimon" General Hospital of Nicea.

The population of the study

The sample consisted of 2805 adults, aged 20–94 years old. Of them, 1375 were men (mean age 49.3 ± 17.3) and 1430 were women (mean age 49.1 ± 17.4). The overall response rate of eligible participants was 91%. Respondents younger than 20 years old were excluded from the study. The age and sex distribution of participants in the survey was compared with Census 2001 data for municipality of Salamis [11]. As shown in table 1, there were only minor differences in distribution by sex and age between the study and the target population. It seems that, the high participation of attendance (86% of registered voters) to the election contributed considerably to obtain a representative sample.

Statistical analysis

Prevalence estimations were made taking into account the stratified sampling procedure. Group comparisons were performed by the use of Pearson's chi-square test. Multiple logistic regression analysis was applied to determine the associations of established risk factors on the presence of diabetes, calculating odds ratio (OR) and their corresponding 95% confidence intervals (CI). Eight risk factors

Table 1: Age and sex stratification of random selected population sample of adult residents in municipality of Salamis, Greece, who participated in survey.

Age group (yr)	Men			Women			Total		
	Population*	Sample	Sampling fraction	Population*	Sample	Sampling fraction	Population*	Sample	Sampling fraction
20–29	2674	246	0.092	1904	267	0.140	4578	513	0.112
30–39	2003	229	0.114	1925	254	0.132	3928	483	0.123
40–49	1680	237	0.141	1817	229	0.126	3497	466	0.133
50–59	1712	222	0.130	1881	227	0.121	3593	449	0.125
60–69	1912	240	0.126	1961	231	0.120	3873	471	0.122
≥70	1513	201	0.133	1645	222	0.135	3158	423	0.134
Total	11494	1375	0.120	11133	1430	0.128	22627	2805	0.124

*Predicted from 2001 census data (11)

Table 2: Age and sex-stratified prevalence of diagnosed diabetes among 2805 randomly selected residents of Salamis, 20 years of age and older – Comparison with "Aegaleo" study results (10).

Age Group	Men	Women	Total	Aegaleo, 1990
	No (%)	No (%)	No (%)	No (%)
20–29	1 (0.4)	–	1 (0.2)	6/2019 (0.3)
30–39	6 (2.6)	3 (1.2)	9 (1.9)	9/1873 (0.5)
40–49	12 (5.1)	6 (2.6)	18 (3.9)	30/1571 (1.9)
50–59	28 (12.6)	25 (11.0)	53 (11.8)	5/1623 (7.7)
60–69	43 (17.9)	35 (15.2)	78 (16.6)	184/1345 (13.7)
≥70	42 (20.9)	44 (19.8)	86 (20.3)	150/875 (17.1)
Total	132 (9.6)	113 (7.9)	245 (8.7)	504/9306 (5.4)
95%CI	8.1–11.1	6.5–9.3	7.7–9.8	4.9–5.9
Age adjusted†	8.5	7.8	8.2	5.9
95%CI	8.35–8.65	7.73–7.87	8.15–8.25	5.87–5.93

No = Number of diabetic subjects † Adjusted to the age distribution of the Greece according to 2001 census data (11)

were tested in the full model: age, sex, education, overweight/obesity, smoking, hypertension, origin and family history of diabetes. Furthermore, a stratified analysis was performed for men and women, respectively. Statistical significance was set at P-value of 0.05. Prevalence of diabetes was age-adjusted by using the direct method based on the 2001 standard population of Greece. SPSS 11 statistical software was used for all statistical calculations (SPSS Inc, Illinois, USA)

Results

The overall prevalence of diabetes was 8.7% or 245 subjects (table 2). After age standardization for the current adult population (2001 census data) of Greece, the projection prevalence was calculated to 8.2% (8.5% among men and 7.8% among women).

The mean age of onset of diabetes was 53 ± 13 years and the mean duration of diabetes was 9 ± 8 years. Seventeen percent of diabetic patients were on diet alone, 69% were receiving antidiabetic agents and 14% reported that were using insulin. The prevalence of type 1 diabetes was low 0.1% (1.2% of the diabetic subjects), so we are referring to type 2 diabetes.

Age and sex

As shown in table 2 prevalence of diabetes increased with age, from 0.2% in the 20–29 years age group to 20.3% in 70 years and older age group (P-value for trend < 0.0001). The odds of diabetes increased by 7% per year, after controlling for various co-factors. Men, in all age groups had a relatively higher prevalence of diabetes as compared to women. The odds of diabetes in men were 1.43-times the

Table 3: Prevalence rates of diabetes mellitus and adjusted effects of potential risk factors in adults aged 20 years and older.

Risk factor	Prevalence of diabetes	Adjusted OR	95% CI	P
Age		1.07	1.06–1.08	0.000
Sex*				
Women†	7.9%	–		
Men	9.6%	1.43	1.04–1.95	0.026
Educational level**				
Higher†	4.1%	–		
Moderate	4.2%	0.87	0.46–1.62	NS
Low	12.9%	1.21	0.71–2.19	NS
Smoking habit**				
Non smokers†	9.0%	–		
Current smokers	6.2%	1.15	0.78–1.69	NS
Former smokers	15.8%	1.30	0.83–2.03	NS
Hypertension**				
No†	5.4%	–		
Yes	24.4%	2.19	1.60–2.99	0.000
Origin from Salamis*				
No†	7.9%	–		
Yes	9.6%	1.23	0.91–1.66	NS
BMI**				
<25†	3.4%	–		
25–29.9	9.8%	1.97	1.29–3.01	0.001
≥30	17.1%	3.76	2.41–5.86	0.000
Family history of diabetes**				
No†	4.1%	–		
Yes	23.9%	6.91	5.11–9.34	0.000

*P > 0.05 (non significant), **P < 0.0001, based on Pearson's chi-square test † Referent group NS = Non Significant (referring to the multivariate analysis)

odds in women, after adjusting for other confounders (table 3).

Educational level

Unadjusted analysis revealed a higher prevalence of diabetes among those with lower education status (table 3). However, the effect of educational level became insignificant after adjusting for several potential confounders like age, sex, overweight/obesity and others variables of the study (table 3). Only among women, the low educational level became significant when controlled for the previous co-factors (OR = 2.62, 95% CI 1.22–5.63, p = 0.014).

Smoking

Thirty-seven percent of the participants reported to be current smokers and 11.3% former smokers. Despite differences in prevalence of DM among current, former and non-smokers, no association was found between smoking and diabetes (table 3). However, the odds of diabetes in former smokers were significantly higher than no smokers, among men (OR = 1.79, 95% CI 1.10–2.90, P = 0.018).

Hypertension

Overall, 20.1% (95%CI 19.2–22.2%) of the participants reported having hypertension. The prevalence of DM among them was significantly higher compared to non-hypertensive people (table 3). Moreover, the odds of diabetes in hypertensive women were higher (OR = 3.10, 95%CI 2.00–5.05, P < 0.0001) as compared to the odds in men (OR = 1.87, 95% CI 1.10–2.48, P = 0.017).

Origin

The prevalence rate of DM was not associated with the origin of the participants (table 3).

Overweight/obesity

Overall, 18.4% of the participants were obese and 44.2% overweight. The counterpart proportions in diabetic patients were 35.9% and 49.4%, while in non-diabetic individuals 16.7% and 43.7%. As it shown in table 4, the prevalence of obesity in 50 years old and younger individuals was higher in men compared to women, while the opposite stands true for ages >50 years old. It is of interest, that after this age sex differences upon diabetes are reduced. It is also noted that obesity rates rise sharply after the age of 30 years, as well as diabetes. The prevalence of

Table 4: Age and sex-specific prevalence of overweight/obesity among 2805 randomly selected residents of Salamis, 20 years of age and older.

Age group (years)	Men		Women		Total	
	Overweight %	Obese %	Overweight %	Obese %	Overweight %	Obese %
20–29	46.3	11.0	19.9	3.4	32.6	7.0
30–39	49.8	20.1	27.2	9.4	37.9	14.5
40–49	56.1	23.6	40.2	14.8	48.3	19.3
50–59	55.9	27.0	43.2	28.2	49.4	27.6
60–69	55.0	22.9	45.5	24.7	50.3	23.8
≥70	59.2	16.4	39.2	22.5	48.7	19.6
Total	53.5	20.1	35.2	16.6	44.2	18.4
95%CI	50.9–56.2	18.1–22.1	32.8–37.7	15.2–19.2	42.4–46.1	16.9–19.8

Overweight: Subjects with BMI = 25–29.99 kg/m² Obese: Subjects with BMI ≥ 30 kg/m²

DM was higher in obese and overweight subjects compared to those with normal weight. When adjusted for age and other potential confounding factors, the effect of obesity and overweight did not change substantially (table 3). The results from the stratified multivariate analysis revealed that the effect of obesity on the odds of having DM was lower (OR = 3.01, 95%CI 1.60–5.68, P = 0.001) in men as compared to women (OR = 4.39, 95%2.40–8.05, P < 0.0001)

Heredity

The prevalence of DM was significantly higher in those with the family history (FH) of diabetes than in those without FH (table 3). Sixty-four percent of diabetic subjects reported positive FH of diabetes vs 19.4% of non-diabetic subjects. The odds of FH of diabetes were 6.9-fold higher compared to subjects without FH, as shown in table 3. After using gender-specific multivariate models we founded that the odds of diabetes among men were higher (OR = 7.66, 95%CI 5.05–11.62, P < 0.0001) as compared to the odds among women (OR = 5.87, 95%CI 3.76–9.15, P < 0.0001).

The proportion of 39.6% of diabetic subjects reported maternal history of diabetes, 18% a paternal history and 26.9% had at least one sibling with diabetes. The adjusted OR of maternal diabetes was 5.6 (95%CI 4.08–7.78), of paternal diabetes was 3.12 (95%CI 2.80–4.67) and 5.38 (95%CI 3.69–7.87) of sibling diabetes.

Combined overweight/obesity with FH of diabetes

The prevalence of overweight with FH of diabetes, among diabetic subjects, was 32.2% and of obesity with FH was 22.4%. The rates among non-diabetic subjects were 4.3% and 9.2%, respectively. Compared to adults with normal weight and without FH, those with combination of over-

weight and FH of diabetes had an OR of 15.24 (95%CI 8.30–27.98) for diagnosed diabetes and those with combination of obesity and FH had an OR of 25.53 (95%CI 13.36–48.77).

Discussion

The present study assessed the current prevalence of known DM in a random sample of urban adult Greek population. To our knowledge, this study is the first that report the prevalence of DM in relation to the most common risk factors such as overweight/obesity, heredity etc, in Greek population.

The sampling, conducted in the elective body of the reference population ensured the representativeness of the sample, for age and sex distribution. The rate of non-participants was relatively low, so the selection bias is considered limited. As an additional strength of this study, could be considered, the finding that the proportions regarding educational level in our sample were similar with those observed for adult Greek population: 52.5% with low education, 31.7% with moderate, 15.8% with higher education and 52.4%, 32.8%, 14.8%, respectively [11]. What was unavoidable in this study is the information bias regarding the source of the data (self-reported), which is leading to the underestimation of the true prevalence of DM. However, despite the potential influences of self-reporting bias this is a common investigated tool used for diabetes surveillance [7,8,12]. Moreover, it has been found that self-reported diabetes was more accurate than self-reported hypertension or heart disease [13].

We found an overall crude prevalence of self-reported DM of 8.7%. After age adjustment for the current adult population (2001 census) of Greece, the projection prevalence was calculated to 8.2%. Thus it could be speculated that

the prevalence of known DM, in Greek adult population, is about 700 thousands patients. The question that is rising is which might be the actual total number of individuals with diabetes, in Greece, taking into account the proportion of previously undiagnosed diabetes, that are likely to have been missed, by this survey. It is reported that the proportion of previously undiagnosed diabetes worldwide is ranged from 32–66% [3,9,14,15]. The only available information in Greece is from a study that was conducted 10 years ago in a semi-urban elderly population ($n = 581$), where an extremely high proportion (65%) of undiagnosed diabetes was found [16]. Based on the fore-mentioned major discrepancies and lack of current data, it is hard to provide a reliable estimation for the Greek population. Nevertheless, based on the lowest reported prevalence of undiagnosed diabetes (32%), it is estimated that about 1.05 million adults have diabetes (a predicted prevalence of 12%). This is a high diabetes burden for a developed European country.

A prior publication concerning a home survey, in 1990, in municipality of Aegaleo at distance of about 10 km from Salamis, found known diabetes in 5.4% of respondents aged 20 years and older [10]. The age-standardized prevalence of diabetes in this population was calculated to 5.9% (table 2). Comparing that prevalence to our findings (8.2%), we observed a 39% increase over the 12 year period (3.3% per year). That increasing prevalence of diabetes in Greek population seems to be higher as compared with the rate between years 1974 to 1990 (2.4 to 3.1%, a rate of 1.8% per year) [10]. These findings suggest that apart from the increase in the prevalence of diabetes, an increased incidence of diabetes probably occurred during the last 12 years. This is in coincidence with a very marked socio-economic evolution that has been experienced in Greece, after 1980s, where the significant improvement of standard livings has dramatically changed lifestyle [17]. Consequently, the increased diabetes prevalence, and perhaps incidence, could be attributed to the adoption of western culture and lifestyle (specifically the interrelated issues of increasing obesity, decreasing physical activity levels and dietary change) [18,19]. However, an increasing prevalence of diabetes does not necessarily implicate an increasing incidence, because the increasing prevalence may reflect better case ascertainment and prolonged survival of diabetic patients as suggested by the findings of Berger et al [20] and Stovring et al [21]. Further studies, mainly longitudinal ones, needs to clarify this issue.

Indicative of the increased prevalence of diabetes in Greece, especially in last decade, are the results of the general population-based study in a municipality of rural Crete, in 1999, where a relatively high age standardized (for European population) prevalence of diabetes (5.2%) was found [22], while the age-standardized prevalence of

known diabetes in another area of rural Crete, in 1988–1993, was 1.5% [23]

In accordance with the current data, our study shows a clear relationship between age and diabetes. Diabetes (type 2) has been considered a disease of middle-aged and elderly. The previous "Aegaleo" studies showed that the increase in diabetes, between 1974 and 1990, begin in those older than 50 years [10], whereas our data shown clearly that the prevalence is increased considerably in both sexes after the age of 30 years (table 2).

A small dominance of men over women ($OR = 1.43$) in diabetes prevalence was observed in our study. A similar difference has been observed in other studies, in Australia where the $OR = 1.31$ [9], in Canada $OR = 1.44$ [11], while others did not reported any sex difference [1,3]. The explanation for these sex differences may be that men are more susceptible than women to the consequences of indolence and obesity, possibly due to differences in insulin sensitivity and regional fat deposition [24].

Previous data showed that prevalence of diabetes (type 2) was inversely related to socioeconomic status [25]. Among socioeconomic status indicators it has been manifested that income is more strongly associated with diabetes prevalence, especially among women [12,26]. In this study, lower educational level was associated with diabetes only among women. Our explanation for this finding is that among Greek female population the educational level might be as strong an indicator for socioeconomic status as income [27].

So far, there are no clear data indicating smoking as an independent risk factor for diabetes, but for diabetes associated complications such as heart diseases [28]. In our study no strong association of smoking and DM was found, finding in concordance with other cross-sectional studies [29]. While the finding that frequency was higher in former men smokers is probably resulting from smoking cessation due to medical advice after development of a macrovascular complication, such as myocardial infarction. However, in contrary to the most of cross-sectional studies there is now evidence from at least five prospective studies to suggest that smoking is associated with increased risk of type 2 diabetes [19].

In a recent telephone-based study, prevalence of hypertension in adults with DM was 56% vs 22% in those without DM (a difference of 34%) [30]. Similar were our results showing that prevalence of hypertension in adults with DM was 51% vs 17% (a difference of 34%), confirming the strong relation between hypertension and diabetes. The result that hypertensive women are more likely to

have diabetes is interesting and warrants further investigation for confirmation.

It is well known that diabetes is strongly associated with obesity [18,31]. Studies in countries with solid information shown that the increase in obesity has been attended strictly by an increase in the prevalence of DM [7,9,32,33]. There is some evidence that rate of obesity, in Greece, has increased in the last decades. This is attributed in considerable changes in nutrition and adoption of sedentary lifestyle [34].

We found that the prevalence of either overweight or obesity among Greek men and women was very high: 73.6% and 51.8%, respectively. Bearing in mind that the risk is increased above a BMI of 25, it is understood that the majority of Greek population is exposed to at least 2-fold increased risk for diabetes. Consequently, these findings have alarming implications for population health and health care expenditure over the next years.

Our findings, compared to the data reported from other similar studies (based on self-reported data), lead to the conclusion that the prevalence of overweight/obesity in Greece is close to USA rates, particularly in older adults [8]. Also, it seems that represents one of the highest obesity rates in Europe [35], confirming the findings of recent study [36].

The study confirms clearly that overweight/obesity is the most important modifiable risk factor for diabetes. Moreover, we found that obesity has a stronger effect on the prevalence of diabetes among women than men, which is consistent with other studies [12]. This finding could have important implications for the prevention of diabetes, because it suggests that targets for the management of obesity should be different: i.e. much stricter for women than men. However, we must be careful in those interpretations, because this study has the disadvantage of being a self-reported data study, where the true prevalence of overweight and obesity is expected to be underestimated by men and women in almost all ages [37,38]. In particular, participants are most likely to recall their height as measured in early adulthood and, as height loss is greatest in the elderly, the difference between their recalled and actual height will be greater. In regard with weight, most subjects under-reported their weight, especially the overweighted subjects [39]. Also, in some studies it was observed that errors in self-reported weight were greater in women than men [40,41]. It is interesting to note that, in this situation of underestimations of the true size of overweight/obesity, a correction procedure – locally calibrated BMI values – which will improve the validity of estimations, is recommended [37,38].

This study not only confirms the important role of heredity in the prevalence of diabetes, but also gives more evidence for this relationship. As a matter of fact, the effect of first-degree FH of diabetes was found to be substantially higher (7-fold) as compared with other countries [1,42,43], indicated that the contribution of genetic background in diabetes varies by ethnic groups. Moreover, our findings add weight to previous reports that diabetes is more likely to be transmitted from mother than from father [44,45].

Although it is recognized that obese people with FH of diabetes are at high risk of developing type 2 diabetes, few population-based studies have quantified the excess risk of the combination of both of them [46,47]. In our study, the synergistic effect of overweight with FH of diabetes was 15-fold and of obesity with FH 25-fold higher compared with normal weight and negative heredity. Practically, these findings suggest that public health target is obesity (as the most important modifiable risk factor for DM), focusing on especially high-risk group of positive heredity for diabetes.

Study limitations

Some limitations of this study are the following. 1) Only data on self-reported diabetes were used, therefore, it was likely to underestimate the true prevalence of diabetes. 2) Also, self-reported data were used regarding the BMI, which was not associated with the correction procedure of locally calibrated BMI values, so the underestimation of obesity and overweight distribution in our sample may exist. 3) We did not take into account the physical activity status that may constitute a strong risk factor for diabetes.

Conclusions

In conclusion, this population-based study provides solid information about prevalence of diagnosed diabetes in urban Greek population, contributing so in the continuing surveillance of diabetes, worldwide, which is essential to predict future disease burdens and prevention strategies.

The study showed that the prevalence of diabetes is high in Greek population and it seems that has increased rapidly, especially in last decade. Also, compared to previous data, we found that diabetes is becoming more common among younger adults.

Our findings suggest that the main modifiable contributing factor is obesity, whose effect extremely increased upon positive heredity presence.

Competing interest

None declared.

Authors' contributions

AG had the original idea for the study, organized the study and contributed to the design, in statistical analyses of the data and writing of the paper. AS contribute to the design, on interpretation of results and preparation of manuscript for publication. DP provided expert advice in study design, data analysis and contributed to the writing of the paper. TP and ES helped to the preparation of the manuscript. SP supervised all phases of the study and manuscript preparation. All authors read and approved the final manuscript

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