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Cost of Follow Up After Endovascular Abdominal Aortic Aneurysm Repair in Patients With an Initial Post-Operative Computed Tomography Angiogram Without Abnormalities

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WHAT THIS PAPER ADDS

Endovascular aneurysm repair (EVAR) has become the preferred treatment for elective repair of infrarenal abdominal aortic aneurysms in the Netherlands. Routine follow up imaging is recommended for all patients following EVAR. However, there is a difference in adherence rates between patients. This study performed an incremental cost analysis and budget impact analysis between patients with continued and discontinued imaging follow up after EVAR. A modest impact would be observed on the Dutch national healthcare budget if de-implementation of yearly imaging follow up was performed.

Objective: The Observing a Decade of Yearly Standardised Surveillance in EVAR patients with Ultrasound or CT Scan (ODYSSEUS) study was conducted to assess differences in outcomes of patients with continued or discontinued yearly follow up after endovascular abdominal aortic aneurysm repair (EVAR). Earlier results of this study showed that discontinued follow up was not associated with poor outcomes. Therefore, an incremental cost analysis and budget impact analysis of de-implementation of yearly imaging following EVAR was performed.

Methods: In total, 1 596 patients from the ODYSSEUS study were included. The expected cost savings were assessed if yearly imaging was reduced in patients with a post-operative computed tomography angiogram without abnormalities made around 30 days after EVAR. Costs were derived from the Dutch costs manual, benchmark cost prices, and literature review. Costs were expressed in euros (€) and displayed at 2019 prices. Sensitivity analysis was performed by varying costs.

Results: A difference of 24% in cost was found between patients with continued and discontinued imaging follow up. The cost per patient was €1 935 in the continued group *vs.* €1 603 per patient in the discontinued group at five years post-EVAR, with a mean difference of €332 (95% bias corrected and accelerated bootstrap confidence interval −741 to 114). De-implementation of yearly imaging would result in an annual nationwide cost saving of €678 471. Sensitivity analysis with variation in adherence rates, imaging, or secondary intervention costs resulted in a saving of at least €271 388 per year.

Conclusion: This study provided an in depth analysis of hospital costs for post-EVAR patients in the Netherlands with a modest impact on the Dutch healthcare budget.

Keywords: Abdominal, Aortic aneurysm, Costs benefit analysis, Endovascular procedures, Retrospective studies
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INTRODUCTION

The introduction of endovascular abdominal aortic aneurysm repair (EVAR) has considerably changed the management of patients with abdominal aortic aneurysms (AAA).[1] Several randomised clinical trials have proven the effectiveness of EVAR compared with open surgical repair (OSR) in the short and midterm post-operative period, yet questions about the cost effectiveness of EVAR remain.[2–5] There is doubt whether EVAR is cost effective due to the high price of endografts,[6] the costs associated with secondary interventions, and the current requirement for permanent imaging surveillance.[7]

International guidelines recommend lifelong imaging surveillance for all patients after EVAR;[8,9] however, adherence rates to yearly post-EVAR imaging surveillance of less

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than 50% have been reported.[10,11] Targeted surveillance based on the first post-operative computed tomography angiogram (CTA) may be valuable, as the risk of complications within the first few years after EVAR is minimal if the first post-operative CTA shows no abnormalities.[12,13]

The Observing a Decade of Yearly Standardised Surveillance in EVAR patients with Ultrasound or CT Scan (ODYSSEUS) study was conducted to evaluate whether the frequency of imaging could safely be reduced in patients with a normal post-operative CTA. Continued imaging surveillance was shown not to confer better survival, indicating an important opportunity to improve the efficiency of the post-EVAR follow up programme in the Netherlands.[14] Secondary intervention rates did not differ between patients with continued or discontinued imaging follow up.

This study hypothesised that a reduction in yearly imaging studies (de-implementation) would probably result in a substantial decrease in healthcare costs. It aimed to examine the costs of all post-EVAR patients having both continued and discontinued yearly imaging surveillance. Additionally, it aimed to perform a budget impact analysis to assess whether the de-implementation of yearly imaging would affect the Dutch healthcare budget.

METHODS

Overview ODYSSEUS study

All consecutive patients who underwent EVAR between January 2007 and January 2012 across 16 centres in the Netherlands were included.[14] Follow up was recorded until December 2018. Patients were regarded as continued or discontinued with yearly imaging surveillance. Continued follow up was defined as undergoing imaging surveillance at least once every 16 months. Discontinued follow up was defined as one missed imaging visit, patient lost to follow up, or if imaging surveillance was suspended due to previous imaging without abnormalities. The primary outcomes were aneurysm related death and secondary interventions. Secondary outcomes included all cause mortality, radiological findings during follow up, and aneurysm rupture. The ODYSSEUS study was performed in accordance with the guidelines for reporting on cohort studies (STROBE)[15] and the protocol was published.[16]

Cost analysis

An economic evaluation was performed of data collected retrospectively from the ODYSSEUS study that compared the cost of healthcare between patients with continued or discontinued imaging follow up. This study was performed from a societal perspective. The actual costs implicated in follow up per patient were calculated, no modelling of the expected costs was performed. All hospital costs per patient were included, including imaging studies with corresponding follow up visits and secondary interventions that were directly related to the initial EVAR.[17] Non-medical costs included travel expenses to the hospital and parking fees. Costs of imaging studies were defined on the basis of the Dutch costs manual 2016,[18] and previous research.[19] The costs of secondary interventions were derived from the Dutch National Health care authority (NZa) and also included the cost of a stay on a surgical ward.[20] Costs associated with the diagnostic pathway before surgery and the additional cost of interventions for wound or access site problems were not taken into account. Travel costs were derived from the Dutch costs manual, and the mean travel distance to the hospital was 7 km.[18] Costs were adjusted to the 2019 price level, using the consumer price index,[18] and calculated per patient. All costs were expressed in Euros (€) and are shown in Table 1. Quality adjusted life years (QALYs) could not be calculated in this retrospective study. The cumulative difference in cost between patients with continued or discontinued imaging follow up was based on the reduction in costs related to the frequency of imaging studies and cost savings due to a reduction in the number of imaging studies and secondary interventions (sensitivity analysis). Another sensitivity analysis was performed to see how redefining the threshold of continued imaging follow up changed the outcome and subsequently the difference in costs. Patients were classified as continued imaging follow up if they underwent at least 80% of their required follow up visits.

Budget impact analysis

A budget impact analysis (BIA) was performed to calculate the effect that the de-implementation of the yearly imaging of EVAR patients would have on the healthcare budget in the Netherlands in relation to health benefits per year. The BIA was based on an estimation of 2000 newly diagnosed patients who would undergo elective AAA repair by means of EVAR in the Netherlands, and an estimation of the number of patients who had been diagnosed in the last five years. The number of newly diagnosed patients was based on data from the Dutch Surgical Aneurysm Audit.[21] The

Table 1. Cost per item of yearly follow up after endovascular aortic aneurysm repair in the ODYSSEUS study patients in the Netherlands *vs.* USA

Item	Cost in the Netherlands (2019) – €	Cost in the USA (2019) – €
CT abdomen	155	574[19]
CTA aorta	346	
Ultrasound	93	121[19]
MRI	245	
Angiography	346	
Visit outpatient clinic	78	
Intervention including surgery ward days		
Radiology	2 628	
Operating room	9 324	
Parking fee	3	
Costs per kilometre	0.19	

All values are expressed in Euros and converted to the 2019 price level using the Consumer Priced Index.[18]

CT = computed tomography; CTA = computed tomography angiography; MRI = magnetic resonance imaging; USA = United States of America.

number of previously diagnosed patients was based on newly diagnosed patients and survival time obtained from the ODYSSEUS study.[14]

Magnetic resonance imaging or angiography (MRI/MRA) and angiography were excluded from the BIA due to their low prevalence. Multiple sensitivity analyses were performed: 1) patients with continued imaging follow up were based on the total observed ODYSSEUS cohort, and patients with discontinued imaging follow up were based on the discontinued imaging follow up cohort (total cohort and discontinued imaging follow up); 2) patients with continued imaging follow up were based on the continued follow up ODYSSEUS cohort, and patients with discontinued imaging follow up were based on a new policy in which all patients underwent one duplex ultrasonography (DUS) examination in the first year post-EVAR (sensitivity analysis new policy). Cost sensitivity analysis was also performed on both an increase and a decrease of 20% over the total of included costs (CTA, CT, DUS, outpatient visit, and secondary intervention). Cost data were collected and presented over a period of five years; the effects and cost generated after the first year were discounted.[18]

Definitions

Follow up time was calculated from the first post-operative CTA at 30 days to the last contact with the hospital, death, or the end of the study period (1 December 2018). To represent lost to follow up, deaths were ascertained by linking data files between the study population and the National Death Register. Follow up data included all imaging studies (DUS, CTA, MRI/MRA, angiography) and secondary interventions. Secondary interventions were EVAR related procedures defined by the Society for Vascular Surgery reporting standards as post-operative adjunctive manoeuvres[17] and divided into secondary interventions performed in the operating room (limb bypass graft, endoluminal repair with cuffs, extensions within primary prosthesis, open or laparoscopic procedures) or radiology department (limb balloon catheter thrombectomy or dilatation, stent placement or coil embolisation). All cost were truncated at five years after EVAR.

Statistical analysis

Continuous variables were expressed as mean and standard deviation (SD) or as median with interquartile range (IQR). Histograms and boxplots were used to assess the distribution of the continuous data. Differences between groups were assessed using the Student's t test or Mann-Whitney U test with normally or non-normally distributed variables, respectively. Categorical variables were presented as numbers and rates, and differences between groups were assessed using the Pearson χ^2 or Fisher's exact test, as appropriate. The actual costs that were made per patient were calculated; no imputation technique was used for missing data. Mean costs were estimated for patients with continued and discontinued imaging follow up with the Student's t test, and bias corrected and accelerated bootstrap (BCa) 95% confidence intervals (CI) were subsequently estimated. Statistical analyses were performed with SPSS software version 26 (IBM, Armonk, NY, USA).

RESULTS

Study population

In total, 1 596 patients were enrolled in this cost and budget impact analysis, including 552 patients with continued and 1 044 with discontinued imaging follow up. Median (IQR) follow up duration for the entire cohort was 89.1 months (52.6) and the cumulative survival at 5 years following EVAR was 73%. By 1 December 2018, 807 of 1 596 patients had died. The cause of death was unknown in 453 patients, due to non-aneurysm related causes in 320 patients, and due to aneurysm related causes in 34 patients. Adherence to continued imaging follow up was significantly related to secondary interventions, aneurysm related, and all cause mortality in multivariable Cox regression analyses. The number of ruptures was 1.8% in patients with continued (10 of 552) and discontinued follow up (19 of 1 044). The mean age of the total cohort was 73.5 years (7.8) and was predominantly male (n = 1 425; 89%).[14]

Cost analysis

Table 2 details the difference in cost during five years following EVAR for patients with continued and discontinued imaging follow up. The total cost five years post-EVAR was €1 068 090 in 552 patients with continued imaging surveillance, and €1 673 394 in 1 044 patients with discontinued imaging surveillance. The cost per patient over five years was €1 935 in the continued imaging follow up group *vs.* €1 603 per patient in the discontinued imaging follow up group, with a mean difference of €332 (95% BCa CI 741 - 114). In sensitivity analysis, the cost of imaging studies was reduced by 10%, 20%, and 30%, leading to differences in cost per patient in the continued *vs.* discontinued imaging follow up group of €275, €288, and €266, respectively. Increasing the cost by 10%, 20%, and 30% the difference in cost per patient in both groups was €352, €374, and €395, respectively. This is shown in Figure 1 and Supplementary Table S1.

No difference between the two groups was observed in the ODYSSEUS study in patients undergoing secondary interventions (89 of 552; 16% *vs.* 136 of 1 044; 13%; p = .091).[14] After five years of follow up there were 82 secondary interventions in the continued imaging follow up group *vs*. 145 in the discontinued imaging follow up group; at the end of follow up this was 129 and 202 secondary interventions in patients with continued and discontinued imaging surveillance.[14] After reducing the costs of secondary interventions in sensitivity analysis by 10%, 20%, and 30%, the resulting difference in cost was €366, €333, and €333, respectively, per patient in the continued *vs.* discontinued follow up groups. The same applied if the costs of secondary interventions were increased by 10%, 20%, and 30%; this resulted in a difference in cost per patient of €331, €329, and €329, respectively (Supplementary Table S1). In

Table 2. Analysis for cost savings at five years in the ODYSSEUS study patients who continued or discontinued yearly follow up after endovascular aortic aneurysm repair in the Netherlands

Variable	Continued imaging follow up (n = 552)		Discontinued imaging follow up (n = 1 044)	
	n	Mean cost per patient – €	n	Mean cost per patient – €
CT abdomen	267	75	463	69
CTA	410	257	467	155
Ultrasound	1 371	231	1 391	124
MRI	2	1	7	2
Angiography	3	2	6	2
Consult	2 051	290	2 334	174
*Intervention**				
Radiology	27	129	36	91
Operating room	55	929	109	973
Travel expenses	4 270	10	4 958	6
Parking	2 135	11	2 477	7
Total costs	1 068 090		1 673 394	
Costs per patient	1 935		1 603	
Mean difference (95% BCa CI)	−332 (−741 to 114)			

All values are expressed in Euros. BCa = bias corrected and accelerated; CI = confidence interval; CT = computed tomography; CTA = computed tomography angiography; MRI = magnetic resonance imaging.
* Stay on the surgical ward is included in the price of the secondary intervention.

sensitivity analysis with the definition of continuous follow up 80%, the cost per patient was €2 017 in the continued imaging follow up group *vs.* €1 188 per patient in the discontinued imaging follow up group, with a mean difference of €829 (95% BCa CI 410 — 1 213).

Budget impact analysis

All costs were converted into cost savings to the Dutch healthcare budget (Figure 2). De-implementation of 90% of yearly imaging studies, based on 2 000 newly treated EVAR patients per year and 6 840 previously treated EVAR patients, resulted in €678 471 cost savings in the first year and €3 131 607 over five years. After performing sensitivity analysis based on the total cohort and patients with discontinued follow up, the total cost savings over five years would be €1 565 804. In sensitivity analysis based on the new policy, in which all patients would undergo one DUS in the first year following EVAR, and 25% would have an endoleak and would therefore go on to have yearly imaging, resulted in cost savings of €2 376 546. An increase in costs of 20% would lead to €1 878 964 cost savings over five years following EVAR. Alternatively, if the reduction in cost was assumed to decrease by 20%, €1 252 643 would be saved.

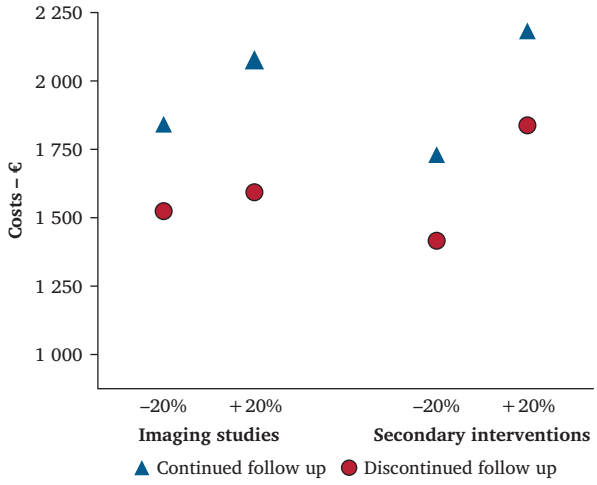
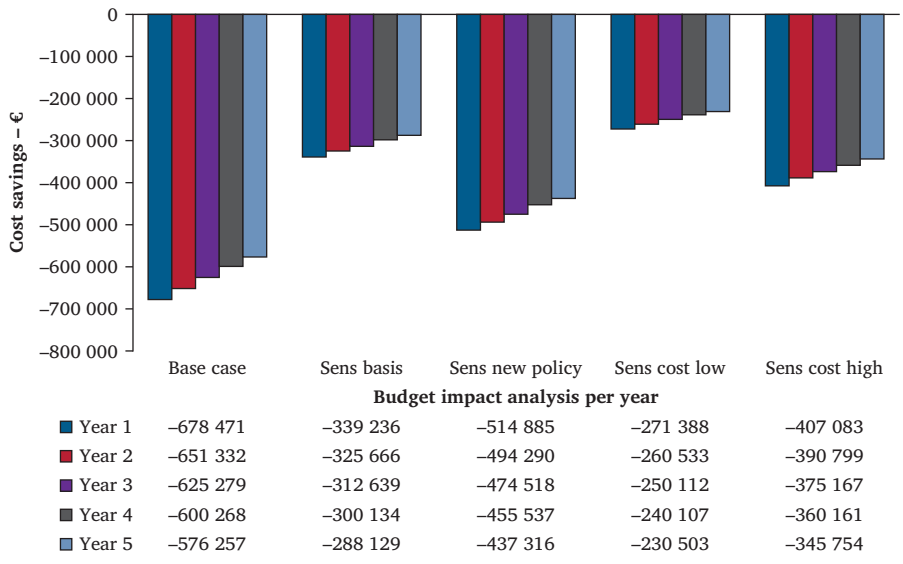


Figure 1. Sensitivity cost analysis with 20% reduction and increase in costs of yearly follow up after endovascular aortic aneurysm repair in the ODYSSEUS study patients in the Netherlands.

DISCUSSION

The results of this study have shown the cost analysis and budget impact analysis of post-placement costs following EVAR included in the ODYSSEUS study.[14] The difference in cost was €332 per patient (24%) between patients with continued and discontinued imaging follow up. Also, based upon a predicted number of 2 000 new patients undergoing EVAR in the Netherlands each year, de-implementation of yearly imaging surveillance could reduce the costs by €678 471 per year. This study examined the budget impact of de-implementation of yearly imaging surveillance based on different circumstances and, in each scenario, this resulted in substantial cost savings of at least €1 252 643 over five years following EVAR compared with the current situation. The difference in cost between OSR and EVAR remains a matter of debate (to the disadvantage of EVAR), particularly due to the high endograft cost.[4,22] The results of observational cost effectiveness studies comparing EVAR with OSR in non-ruptured AAAs are still conflicting, indicating EVAR to be both more[5] and less cost effective.[23] Earlier studies have



Budget impact analysis per year

	Base case	Sens basis	Sens new policy	Sens cost low	Sens cost high
Year 1	–678 471	–339 236	–514 885	–271 388	–407 083
Year 2	–651 332	–325 666	–494 290	–260 533	–390 799
Year 3	–625 279	–312 639	–474 518	–250 112	–375 167
Year 4	–600 268	–300 134	–455 537	–240 107	–360 161
Year 5	–576 257	–288 129	–437 316	–230 503	–345 754

Figure 2. Budget impact analysis per year after de-implementation of yearly imaging surveillance after endovascular aortic aneurysm repair in the Netherlands based on the ODYSSEUS study cohort. Base case = patients with continued *vs.* discontinued imaging follow up based on the original ODYSSEUS cohort; Sensitivity (Sens) base = patients with continued imaging follow up were based on the total observed ODYSSEUS cohort, and patients with discontinued imaging follow up were based on the discontinued imaging follow up cohort (total cohort and discontinued imaging follow up); Sensitivity new policy = patients with continued imaging follow up were based on the continued follow up ODYSSEUS cohort, and patients with discontinued imaging follow up were based on a new policy in which all patients underwent one DUS examination in the first year post-EVAR; Sensitivity cost low = decrease of 20% over the total of included cost (CTA, CT, DUS, outpatient visit and secondary intervention); Sensitivity cost high = increase of 20% over the total of included cost (CTA, CT, DUS, outpatient visit and secondary intervention). CT = computed tomography; CTA = computed tomography angiography; DUS = duplex ultrasonography.

mainly compared the differences in cost between EVAR and OSR,[4,5,19,22] and not all of them included follow up costs in their analysis. A Dutch study by Bulder *et al.* concluded that the total costs were lower in the EVAR group than in the OSR group for endovascular devices costing up to €13 000.[19] Large variability still exists in cost for EVAR, depending on different factors such as endograft type, year of operation, and the healthcare system. In the current cohort the cost drivers were secondary interventions, clinical consultations, and imaging studies. Noll *et al.* reported that secondary interventions accounted for almost 60% of the post-EVAR costs.[24]

The budget impact analysis varied between €678 471 in the first year to €576 257 at five years post-EVAR after indexation; the total budget impact over five years was €3 131 607. This potential budget impact analysis model recommended that de-implementation of yearly imaging surveillance has the potential to save the Dutch healthcare system a modest amount of money. Money resources will be spared in the healthcare system without compromising patient safety. Yet, consideration must be given to achieving more cost savings, for example: to refrain from surgical repair in frail patients.[25] Cost savings could also be generated by increasing the follow up interval in patients with a stable aneurysm sac diameter. In the Netherlands, discontinued follow up was not associated with worse outcomes.[14]

Another important issue to address is that the number of secondary interventions that may be required in the future is difficult to predict. The current study predicted the current follow up costs up to be €1 935 per patient in the group with continued follow up, and €1 603 per patient in the group with discontinued follow up; however, current follow up protocols are likely to change. Recent studies also found that less imaging following EVAR does not harm patient outcomes.[11,14,26] In addition, a new generation of endovascular devices,[27] more experienced vascular surgeons,[28] and a more conservative approach towards type 2 endoleaks[29] might reduce the follow up cost after EVAR in the near future. The use of DUS for EVAR surveillance to assess sac diameter is established[30] and will contribute to a decrease in per year cost of imaging follow up.

This study had several limitations. First, discontinued imaging follow up in this study was defined as not undergoing yearly imaging for 16 months; patients missing one examination were classified as discontinued to imaging follow up and therefore this could have led to an underestimation. The timing of the first post-operative CTA after EVAR and its impact on outcomes was not assessed. De-implementation of yearly imaging surveillance following a normal initial CTA could lead to different outcomes, and the recommendation should therefore be interpreted with caution. Also, patients were included until 2012; therefore, aspects of time related effect modification may have impacted conclusions.

Second, these cost structures may not directly translate to other countries or healthcare systems. Since surveillance protocols can also differ between centres in the Netherlands, the costs of imaging surveillance may be different in various centres and will depend on the combination of imaging follow up modalities. Also, cost data and events were collected only if patients returned to the participating hospitals and it is possible that some patients were followed up at a non-participating hospital and underwent imaging surveillance (including imaging for post-EVAR follow up or other purposes) elsewhere. This may have led to an underestimation of the costs, as the outcomes may have been affected by attrition bias. Only costs of de-implementation of yearly imaging were assessed, no statement can be made regarding cost effectiveness (e.g., QALY). Furthermore, the cost of imaging surveillance after EVAR was based on local data published in 2014 and 2015. Given that healthcare costs in the Netherlands increased by 10.0 − 10.3% every year between 2015 and 2019, it is possible that the costs in this study may have been underreported.[31]

The main strength of this study was the duration of the long term follow up. This time span made it possible to incorporate most of the surveillance related hospital costs and to capture the majority of secondary interventions during follow up. The present study increases the information available on efficiency of de-implementation of yearly imaging after EVAR and its substantial impact on the Dutch healthcare system. Also, since the results of the retrospective ODYSSEUS study showed that discontinued imaging follow up was not associated with poor survival rates, de-implementation of yearly imaging following EVAR may be reconsidered in patients without abnormalities at their initial CTA. Following the potential EVAR surveillance protocol with reduced imaging intensity suggested in the 2019 European Society for Vascular Surgery Guidelines, this will lead to a decrease of 30 to 50% in patients without an endoleak and with adequate seal that do not require imaging follow up to five years, and thus in imaging follow up and cost.[8]

CONCLUSION

Based on the 1 596 included patients, de-implementation of yearly imaging after EVAR may lead to €678 471 cost savings per year in the Netherlands. This cost and budget impact analysis demonstrated that if de-implementation of yearly surveillance were to be included in the current guidelines, there would be a minimum impact on health outcomes for patients who undergo EVAR, and a modest impact on overall healthcare expenditure.

CONFLICTS OF INTEREST

None.

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APPENDIX A. ODYSSEUS STUDY GROUP COLLABORATORS.

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APPENDIX B. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejvs.2022.08.031.

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