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CAUSAL FRAMEWORK ON THE DETERMINANTS OF DELIVERY EXPENDITURE IN EMILIA-ROMAGNA REGION, ITALY

Abstract:

The vast numbers of studies have been undertaken in order to detect the influence of social and biological factors on pregnancy outcome, though none of them described the causal framework of the delivery cost. The structure of the delivery expenditure can be viewed as a complex mechanism where socio-economic, environmental and biological variables enter into account. The aim of this study is to construct a conceptual framework of the determinants of delivery expenditure with highlighting the impact of maternal smoking to the cost. Analysis was based on an Italian administrative data composed from records of epidemiological, socio-demographic and organizational data. The population of interest consisted of 2381 new-borns born between January and June in 2010 in Emilia-Romagna, and those mothers indicated one of the following smoking status: stopped smoking in the last 5 years prior to pregnancy, stopped smoking at the beginning of pregnancy, continued to smoke during pregnancy.

Keywords:

Maternal smoking, delivery cost, conceptual framework

JEL Classification: C19

Introduction

The study of the impact of maternal smoking on the delivery cost is not new. However, most of these studies interpret these relations in terms of associations, if the effects appear significant in the statistical analysis.

The causal framework on the determinants of the delivery expenditure was not described in previous studies. Nevertheless, the vast numbers of researches have been undertaken in order to detect the influence of social and biological factors on pregnancy outcome. The socioeconomic, environmental factors, the wide range of maternal health and behaviour factors were associated with adverse pregnancy outcome (Anandalakshmy el al. 1993; Graham and Murray 1997; McCarthy and Maine 1992; Magadi et al. 2001; Mohamed et al. 1998; Magadi et al. 2004).

The aim of this paper is to construct causal framework on the determinants of the delivery expenditure and test it using data from Emilia-Romagna region. The study analyse the effect of smoking on the delivery cost with an approach allowing the interpretation of the results of the statistical analysis as causal effects.

Methodology

Theoretical framework

The formal framework of structural modelling is presented by the hypothetico-deductive methodology (Mouchart et al. 2009; Mouchart et al. 2010). Hypothetico-deductivism is a view according to which the scientist first formulates a hypothesis and then tests it by seeing whether the consequences derived from the hypothesis obtain or not. Model building and model testing is performed through two stages:

- formulating the causal hypothesis
- building the statistical model and then drawing consequences to conclude to the empirical validity or invalidity of the causal hypothesis.

The statistical model is based on the decomposition of the joint distribution of the set of variables through conditional and marginal distributions. The conditional variables of each conditional component of the decomposition are exogenous variables for the corresponding sub-process.

A model to consider as structural, at least two conditions have to be fulfilled. It has to be coherent from a theoretical point of view and the parameters of the model should be stable.

Conceptual framework

The general idea behind the construction of the conceptual framework is to highlight the causal mechanisms leading to a particular event. The causal framework presented in Fugure 1 expresses all causal relations between the different determinants of delivery

cost. The model includes six groups of variables: socio-economic, enviromental and behavioral charcteristics, maternal characteristics, pregnancy outcome and medical realization, and the cost:

- Socio-economic characteristics [**SEC**] includes parents socioeconomic circumstances, education, partnership and parenthood histories (Graham and Der 1999; Graham et al. 2006; Leonardson et al. 2007; Martin et al. 2007; Branis and Linhartova 2012; Vrijheid and Martinez 2012; Zhang and Hayward 2006; Hughes and Waite 2009; cundiff et al 2013).

- Enviromental characteristics [**EC**] encompass enviromental tobacco smoke, air pollutants from motor vecihles and industrial facilities, water, food and a myriad of consumer products and other substances that individuals come into direct contact with each day (Kodgule and Salvi 2012; surdu et al. 2013; Foss et al. 2011; Morales-Suarez-Varela et al. 2010; Atkinson et al. 2013; Pope et al. 2010; Lakshimi et al.).

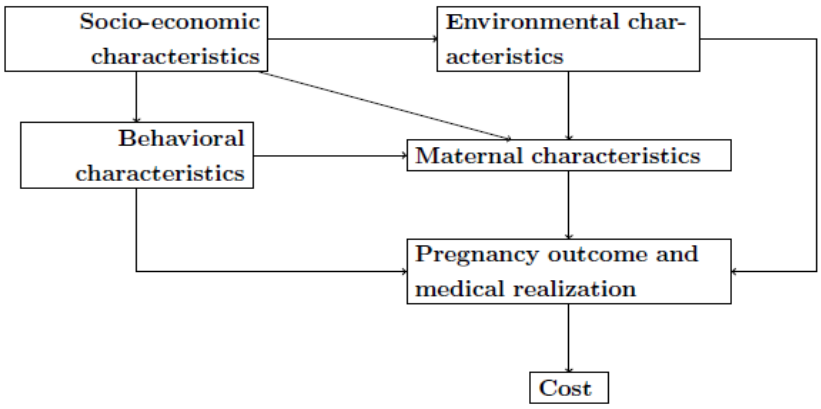
- Behaviour characteristics [**BC**] combine preventive health behaviour such as prenatal care, nutrition, and use of drugs, tobacco, and alcohol (Poli et al. 2013; Bjerkaas et al. 2013; Holma et al. 2013; Grella and Lovinger 2012; Arias and Viner-Brown 2012; O'Leary et al. 2010; Black et al. 2013; Catov et al. 2011).

- Maternal characteristics [**MC**] include the general physical and psychological health state of mother at impregnation and during pregnancy, and the reproductive history of mother (Morton et al. 2013; Mulder et al. 2002; Klementti et al. 2012).

- Pregnancy outcome and medical realization [**POMR**] include all variables linked to the pregnancy outcome and medical assistance. Pregnancy outcome is related to information about delivery and newborn (fetal position before birth, weight at birth and etc.). During delivery there can be some extra medical assistance as pediatrician, anesthetist or other. As well there exists differences across the hospital themselves. Some of them are more equipped due to their financial support or to their competenceis.

- Cost [**COST**] refers to the cost of delivery and the cost of hospitalization during first six months after the birth.

Figure 1: Conceptual framework



Statistical model

The Figure 1 represents costs as a recursive system in which all the variables are linked through a direct acyclic chain, that is, each variable depends on its predecessors and there are no feedback relations. The absence of arrow between two determinants indicates that these two indicators are conditionally independents.

The process leading to the cost can be decomposed into the product of marginal and conditional probabilities:

$p(COST, POMR, MC, EC, BC, SEC|\theta) =$

$p(COST|POMR,\theta_{COST}) * p(POMR|MC,EC,BC, \theta_{POMR}) * p(MC|EC,BC,SEC, \theta_{MC})$

$* p(BC,EC|SEC, \theta_{BC,EC}) * p(SEC|\theta_{SEC}),$

where $\theta_{COST}=\theta_{(COST|POMR)}$, $\theta_{POMR}= \theta_{(POMR|MC,EC,BC)}$, $\theta_{MC}=\theta_{(MC|EC,BC,SEC)}$, $\theta_{BC,EC}=\theta_{(BC,EC|SEC)}$ and $\theta=(\theta_{COST}, \theta_{POMR}, \theta_{MC}, \theta_{BC}, \theta_{EC}, \theta_{SEC})'$ is the vector of the parameters of multivariate distribution. This decomposition corresponds exactly to the DAG presented by the conceptual framework in Figure 1.

In latter formula each of conditional densities represent a structural process and the parameters of these conditional densities are independent of each other, this means that the conditional densities could consequently be individually estimated without loss of information: the parameter of conditional density is not influenced by parameters of other conditional densities.

Data

The final data set arises from a complex work of data manipulation of different types of data: administrative data based on survey (CedAP) and purely administrative data (SDO).

CedAP – Birth Assistance Certificate – provides health, epidemiological and socio-demographic information through the survey on births (more information: www.saluter.it/siseps/sanita/cedap/documentazione).

SDO – Hospital Admissions – consists information on hospital admissions recorded by hospitals and nursing homes through discharge papers. The information describes clinical and organizational aspects of hospitals (more information: www.saluter.it/siseps/sanita/sdo/documentazione).

The set of selected indicators and their description are presented below:

Table 2: Description of the selected data

Label	Code	Categories
Socio-economic characteristics		
Mother:		
Maternal age	MA	<25, 25-29, 30-34, 35-39, 40+
Marital status	MS	Single (1), married (2), separated (3), divorced (4), widowed (5), not stated (6)
Nationality	MN	Italian, other EU, citizen of LMLIC*, other
Place of birth	MPB	Italy (north-east, north-west, central, south, islands), abroad, n/a
Education level	ME	Primary or no education (1), secondary (2), high school (3), tertiary (4)
Current occupation status	MCOS	Occupied, unemployed, in search of first job, student, housewife, other, n/a
Father:		
Parental age	FA	<25, 25-29, 30-34, 35-39, 40+, n/a
Nationality	FN	Italian, other EU, citizen of LMLIC*, other
Education level	FEL	Primary or no education, secondary, high school, tertiary
Current occupation status	FCOS	Occupied, unemployed, in search of first job, student, housewife, other, n/a
Environmental characteristics		
Mother:		
Profession	MP	Self-employed, manager or director, employee, worker, other dependent employee, n/a
Sector of employment	MSE	Agriculture, hunting and fishing, industry, services, public administration, other private sector, n/a
Father:		
Profession	FP	Self-employed, manager or director, employee, worker, other dependent employee, n/a
Sector of employment	FSE	Agriculture, hunting and fishing, industry, services, public administration, other private sector, n/a
Behavior characteristics		
Smoking	SM	stopped smoking in the last 5 years prior to pregnancy (1), stopped smoking at the beginning of pregnancy (2), was smoking during pregnancy (3)
Amniocentesis	AC	yes, no, n/a
Chorionic villus sampling	CVS	yes, no, n/a
Fetoscopy	FT	yes, no, n/a

Number of control visits	NV	0-5, 6,7,8,9+
Number of pregnancy ultrasound	NE	0 (1),1-3 (2), 4+ (3)
Maternal characteristics		
Hospitalization during pregnancy	HP	yes, no, n/a
Number of previous:		
Live births	NB	0, 1, 2, 3+
Spontaneous abortion	NSA	0, 1, 2, 3+
Induce abortion	NIA	0, 1, 2, 3+
Cesarean	NC	0, 1, 2, 3+
Pregnancy outcome and medical realization		
Type of hospital	TH	Public type A, public type B, private
Method of labour	ML	Spontaneous, induced, without
Reason of induction	RI	Prolonged pregnancy, oligodramnios, premature rapture of membranes (PROM), maternal pathology, fetal pathology, n/a
Type of induction	TI	Prostaglandin, oxytocin, other drug, amnioressi, other mechanical method
Anti-pain method used in labour	AntiM	No method used, epidural analgesia, other type of pharmacological analgesia, non-pharmacological method, n/a
Method of delivery	MD	Vaginal (non-assisted), vaginal with use of forceps, vaginal with use of ventouse, cesarean
Fetal position before birth	FPBB	Facing down 1, facing down 2, facing upward 1, facing upward 2, feet first, lying sideways
Weight at birth	WB	<1500, 1500-2499, 2500-3499, 3500+
Presence of malformation	PM	Yes, no, n/a
Type of resuscitation	TR	Manual ventilation, intubation, not required
Presents during pregnancy:		
Pediatrician/monatologist	PP	Yes, no, n/a
Anesthetist	AP	Yes, no, n/a
Neonatal nurse	NP	Yes, no, n/a
Cost		
Cost	COST	Categorical

The indicators available from the CedAP and SDO data sets are far from being perfect. For the behavior characteristics, the database includes only the smoking status and prenatal care characteristics. Alcohol and drug habits as well as nutrition are not available. For the maternal variables, the past reproductive history is well represented, however, we do not have much information on the health status of the mother or any information about exposure to stress during pregnancy. Information on the environmental characteristics is also relatively substantial: parent's profession and sector of employment.

The variable COST have been discretized and replaced with five categories variable (using 20, 40, 60 and 80 percentiles).

Results

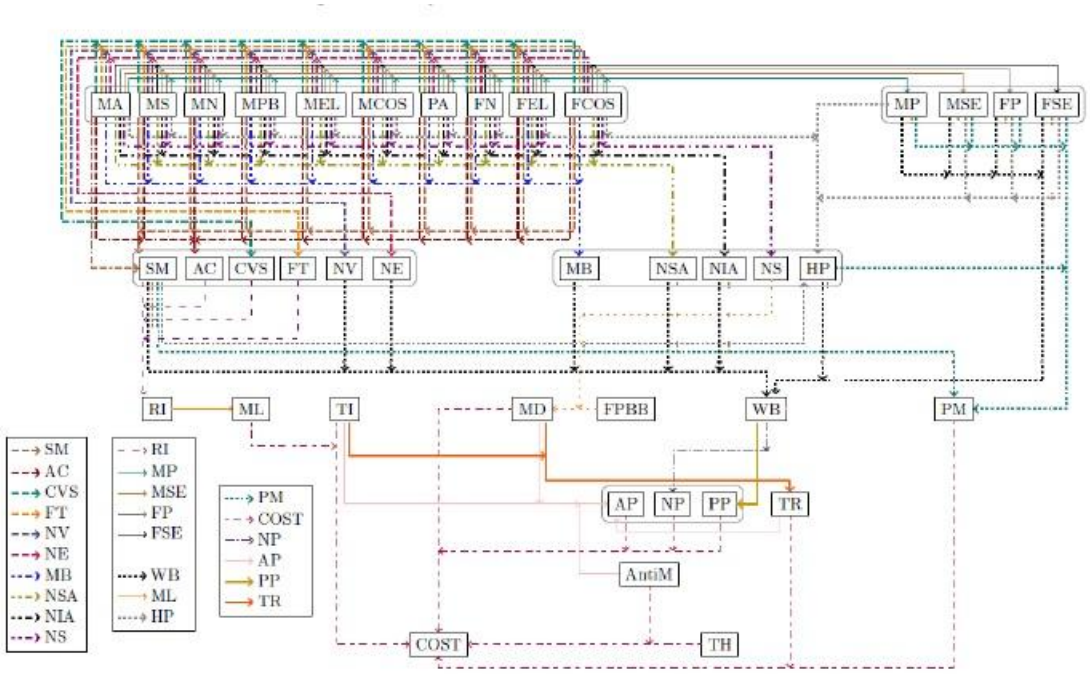
Operational framework

The operational framework corresponds to the conceptual framework where the theoretical determinants are replaced by their indicators. The causal mechanisms are represented in the operational framework (Figure 3) on the basis of the observed variables.

Estimation Method

The data can be presented by a matrix Z of dimension N×M where N is the number of observation and M is the number of variables. We can say that Z is composed of a set of endogenous variables Y and a set of exogenous variables, X; Z=[Y X] with Y of dimension N×J and X of dimension N×S. In other words, the process of interest is the distribution of Y with respect to X. Each of endogenous variables is estimated through ordered logit model. Such a model estimates the conditional probability that a particular event is below a given level *k*.

Figure 3: Operational Framework



The structural model of delivery cost is consequently composed of 24 equations and some of them are represented below:

$$\text{Logit (SM)} = \alpha_{SM} + \beta_{SM,MA}*MA + \beta_{SM,MS}*MS + \beta_{SM,MN}*MN + \beta_{SM,MPR}*MPR + \beta_{SM,MEL}*MEL + \beta_{SM,MCOS}*MCOS + \beta_{SM,PA}*PA + \beta_{SM,FN}*FN + \beta_{SM,FEL}*FEL + \beta_{SM,FCOS}*FCOS$$

$$\text{Logit (PM)} = \alpha_{PM}+\beta_{PM,SM} *SM+ \beta_{PM,HP}*HP + \beta_{PM,MP}*MP+ \beta_{PM,MSE}*MSE+ \beta_{PM,FP}*FP + \beta_{PM,FSE}*FSE$$

$$\text{Logit (WB)} = \alpha_{WB}+\beta_{WB,HP} *HP+ \beta_{WB,SM}*SM + \beta_{WB,NV}*NV+ \beta_{WB,NE}*NE+ \beta_{WB,MB}*MB + \beta_{WB,NSA}*NSA+ \beta_{WB,NIA}*NIA+ \beta_{WB,MP}*MP + \beta_{WB,MSE}*MSE+ \beta_{WB,FP}*FP+ \beta_{WB,FSE}*FSE$$

$$\text{Logit (TR)} = \alpha_{TR}+\beta_{TR,MD} *MD+ \beta_{TR,TI}*TI$$

$$\text{Logit (PP)} = \alpha_{PP}+\beta_{PP,WP} *WB$$

$$\text{Logit (NP)} = \alpha_{NP}+\beta_{NP,WP} *WB$$

$$\text{Logit (AP)} = \alpha_{AP}+\beta_{AP,AntiM} *AntiM+ \beta_{AP,TI}*TI + \beta_{AP,MD}*MD+ \beta_{AP,TR}*TR$$

$$\text{Logit (COST)} = \alpha_{COST}+\beta_{COST,TH}*TH+ \beta_{COST,PM}*PM+ \beta_{COST,ML}*ML+ \beta_{COST,AntiM}*AntiM + \beta_{COST,TR}*TR+ \beta_{COST,TI}*TI+ \beta_{COST,MD}*MD+ \beta_{COST,AP}*AP+ \beta_{COST,PP}*PP + \beta_{COST,NP}*NP$$

Main Findings

In this paper we will present the main findings (for more details, see Balinskaite 2014).

Figure 4 presents graphical representations of the odds ratio for education, maternal smoking status and weight at birth. Graphical representation of the odds ratios for maternal education (Figure 4: a)) and marital status (Figure 4: b)) indicates that it influences the maternal smoking status.

The odds ratio [smoked during pregnancy/stopped smoking in the 5 years prior to pregnancy] is 0.78, with small confidence interval (Figure 4: c)). This shows that women, who smoked during pregnancy, have a higher risk to deliver a baby with lower birth weight. As well, the number of pregnancy ultrasounds shows the significant impact on the weight at birth (Figure 4 e)).

Graphical representation (Figure 4: e)) of the odds ratio for weight at birth indicates that it influences the presence of pediatrician. The odds ratio goes from 0.12 (95% CI: 0.03-0.5) for a category [<1500] to 1.02 (95% CI: 0.86-1.2) for category [3500+] (category of reference is [2500-3499]).

Medical realization indicators such as type of hospital, method of delivery and type of resuscitation have a marked impact on the cost. For the type of resuscitation, the odds ratio goes up from 1.34 for manual ventilation to 1.37 for an intubation (category of reference is ‘not required’); though the confidence intervals for second care are rather large. The effect of type of hospital and method of delivery are easily explained, as the cost is defined according to the regional and national normative documents (act no. GPG/2011/199). For example, the cost of the caesarean section in hospital type A starts

from 2031.48 € (1895.05€ in hospital type B), while the cost of vaginal delivery in hospital A and B starts from 220€.

The odd ratio for presence of pediatrician at birth with respect to reference category ‘not presence’ is 0.94 indicates that presence of pediatrician during delivery is associated with higher odds of the cost. And finally, the presence of malformation appears as well as one of the determinants of the cost. The odds ratio [presence of malformation/no presence of malformation] is 1.34, showing that newborns with malformation are more likely to increase the health care expenditure.

Discussion and conclusion

Causality is fundamental to our understanding of the nature world. Causal statements are part of everyday speech, as well as legal, scientific and philosophical vocabulary. Human being reaches an intuitive consensus on the meaning of many causal utterances and there have been numerous attempts to formalize causality in a way that it is faithful for that consensus.

The construction of the conceptual framework was based on a review of literature and represents theoretically possible causal effects of the determinants of the delivery expenditures. When the determinants in causal framework were replaced by available data and the estimation method was based on decomposition of joint distribution and the estimation of parameters through ordered logit model.

Nonetheless, it has few limitations. First of all, it requires reliable prior information which is based on actual knowledge of the theoretical pathway and it does now detect unknown or unexpected causal relations, and each significant causal relation could still partly explained by unknown (from theoretical point of view) common causes. A second issue is related to the known confounders which can be incorporated into the model only upon the condition that indicators of these confounders are available in the data set. Another limitation is concerning the stability of the model which must be fulfilled. To do that, different databases (from another year or from another region) with similar sample size is needed and this was impossible to achieve.

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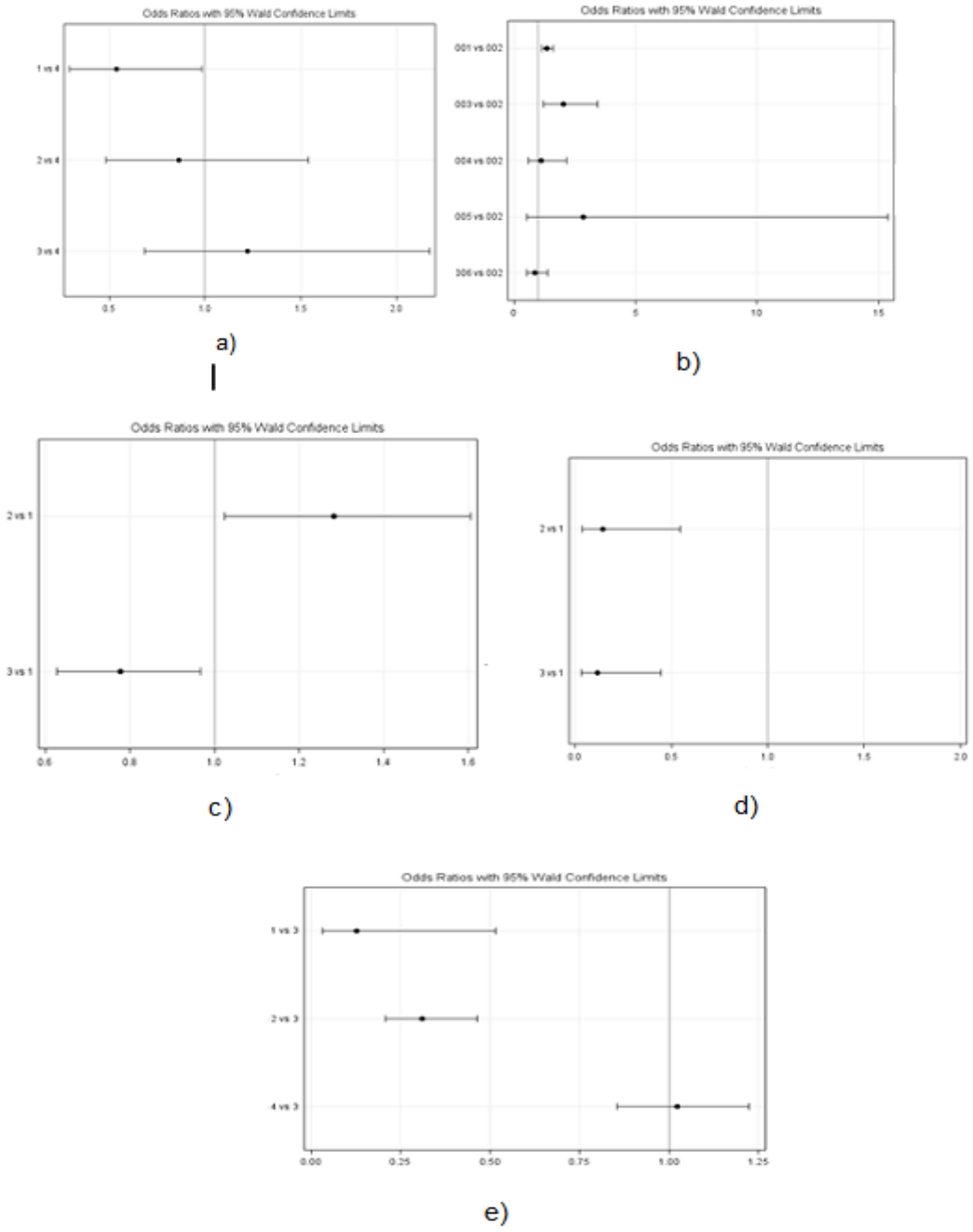
Figure 4: Odds Ratios



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