Predictive Modeling of Delivery Mode and Cesarean Section Risk Using Decision Trees

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ABSTRACT

Background: The rate of cesarean section has been increasing worldwide and particularly Tamil Nadu has more than 60% of cesarean section.
Objective: The purpose of this study is to affirm and suggest that decision tree model can be used to predict the mode of delivery and the risk factors associated with cesarean delivery.
Study design: This is a study of women delivered live-born neonates in 2015 through 2017 (4043). The frequency of cesarean delivery is 61.61%; 33 variables are used for analysis. Decision tree model is applied to the 50% of the sample dataset to develop the predictive training models and the same is applied to the remaining 50% dataset. This method is applied on the sample data and the outcomes are tested to predict the mode of delivery.
Results: 4043 women who had attempted delivery are included in the study. The overall modes of delivery are cesarean delivery (61.61%) and vaginal delivery (38.39%). The risk factors that are associated with cesarean delivery are age, height, BMI, child weight, HBP, sugar, thyroid, toxemia, multiple pregnancies, breech presentation, sleep disturbance. The highest risk for cesarean delivery of the patients can still have a 50% possibility to vaginal delivery.
Conclusion: Decision Tree model can be used to predict the delivery mode. Applying this method to both training and testing dataset, the accuracy of the outcomes produced is 100% and 99.50%. However, the patients at highest risk for cesarean delivery have 50% possibility of successful vaginal delivery and therefore should be allowed to attempt vaginal delivery.

Keywords: Arrest of Labor (AoL); Cesarean delivery; Multiple gestation; Amniotic fluid; Breech presentation; Decision Tree.

I. INRTODUCTION

In Maternity Care, a quick decision has to be made about the most suitable delivery type for the current patient. Guidelines are followed by the gynecologist to support that decision; however, the practice recommendations are limited and underused. In the year 2016, the private hospitals have produced 55.2% of delivery by cesarean in rural areas and 48.6% in urban areas. A similar trend has been noted around the world, in both the developed and developing countries.[1]Obstetric and pregnancy factors are analyzed, which can be used to predict the most appropriate delivery technique, through the induction of data mining models using real data gathered in the perinatal and maternal care unit of Government Hospitals, Primary Health Centre and Public (GPP).

Several techniques are used to perform deliveries in Maternity Care. Commonly, the delivery procedures are addressed as vaginal deliveries and cesarean sections (CS). Predicting the most accurate delivery mode in advance would allow identifying which pregnant women actually need cesarean section, reducing the proportion of unnecessary assisted procedures used substantially with trivial medical benefit.[2] Furthermore, by supporting the gynecologist in decision-making process, the healthcare service would be able to avoid malpractice and negligence, leading to quality improvement in maternity care and pregnant women.[3]

The purpose of this study is to induce Data Mining (DM) classification models to predict the type of delivery more compatible with the pregnancy characteristics of each patient. The required information is provided by the information systems and technologies used in the perinatal and maternal care units of Government Hospitals, Primary Health Centre and Public (GPP). The database with multivariable methods has determined that mother's age, first delivery and previous cesarean delivery[4]. maternal diabetes, hypertension, pre-eclampsia, HBP, Thyroid, fetal presentation[5] and weight, Body Mass Index (BMI)[4,6] and multiple gestation are the factors associated with cesarean delivery. Maternal heights are primarily self-reported. Weight gain is taken as the difference between the first recorded weight and the last recorded weight in the women who were seen before 20 weeks of gestation. The first recorded weight or initial weight and final weight are used for the calculation of

BMI. The diagnosis of breech virtually guaranteed that there is no attempt at vaginal delivery.[7,8]Regardless of the other diagnosis, decrease in the level of amniotic fluid in the uterus which affects the fetal movement, use of medications during pregnancy and arrest of labor (AoL), result in the cesarean section.[7,9]

The strongest of these include increased maternal age, particularly at the time of first delivery,[10-13] as well as the mother being overweight.[14,15] In addition, once CS has been done, the most likely mode of delivery in later pregnancy is CS.[16-19] Higher socio-economic status and possession of private health insurance are also associated with higher rates of CS.[20,21] Findings from two recent studies provide evidences that a history of former psychiatric conditions or mental health problems reported during pregnancy, are related with increased rates of CS.[22,23] Although nervousness and fear of childbirth are the commonly reported reasons for women requesting elective cesarean delivery in several international studies.[19,24] Cesarean delivery before 39 weeks of gestation increases the risk of morbidity among infants. [25]

II. PARTICIPANTS AND METHODS

Background

Unwanted caesarean is against for woman's harassment. Nowadays the normal deliveries have reduced and the caesarean deliveries have increased. The C-Section is dangerous and instil fear in women. Many hospitals provide wrong guidance to the women to operate the C-section instead of normal delivery, even though they want the normal delivery. But some hospitals forced caesarean delivery instead of normal delivery.

The private hospitals have produced 55.2% of caesarean delivery in rural area and 48.6% of caesarean delivery in urban area of Tamil Nadu. Whereas, the government hospitals have produced 25% of caesarean delivery in rural areas and 28% in urban areas. According to the report by ICMR School of Public health, the rate of caesarean births in Kerala was 41% and 58% in Tamil Nadu in the year of 2015. 80% of women had undergone caesarean delivery in some districts of Andhra Pradesh based on the research survey. Among the various districts in Tamil Nadu, Thiruvarur district has the highest rate (76.9%) of caesarean deliveries and the Theni district has the next highest rate (75.4%) of caesarean deliveries. The least rate of caesarean delivery was found in the Villupuram district. 11.1% in government hospitals and 26.8% in private hospitals. Various surveys report that most of the caesarean deliveries occur only in the private hospitals.

As per the census, it was reported that the surgeons do many caesareans to many innocent and illiterate pregnant ladies by forcing them, even though they want the normal delivery. Unnecessary caesarean is a kind of violence against women.

Ministry of Family Welfare point out some information in their survey 2015 – 2016.

District	% of Caesarean Deliveries in Private Hospitals	% of Caesarean Deliveries in Govt. Hospitals	Total Percentage
Ariyalur	60.5	35.1	39.9
Chennai	33.6	25.5	28.8
Cuddalore	54.6	37.4	40.4
Coimbatore	64.3	29.6	41.4
Dharmapuri	63.8	19.3	27.3
Dindugal	48.9	25.1	30.4
Erode	53.7	23.3	31.2
Kanchipuram	42.5	31.7	35.5
Kanyakumari	56.7	40.3	51.3
Karur	58.8	28.3	40.1
Krishnagiri	51.4	16.5	24.1
Madurai	55.5	28.3	40.1
Nagapattinam	60	32.3	39.8
Namakkal	53.2	21.1	32.6
Perambalur	56.4	37.2	44.9
Pudukottai	62.6	29.9	39.9
Ramanathapuram	51.2	31.2	40.9
Salem	63.1	16.6	30.5
Sivagangai	52.6	37.3	42.8
Thanjavur	63.6	33.5	43

Theni	75.4	21.6	34.8
Thiruvallur	49.2	32.8	37.1
Thiruvarur	76.9	25.9	42
Thoothukudi	42	34	37.1
Trichy	55.8	22.7	37.3
Tirunelveli	46.3	28.7	37.6
Tirupur	36.8	34.3	35
Thiruvannamalai	41.2	16.7	18.7
Vellore	38.9	20.3	25.7
Villupuram	26.8	11.1	13.3
Virudhunagar	56.4	38.1	43.2
Nilgiri	34.5	23.3	26.3

In critical section, the caesarean delivery can be allowed, but the doctors performing caesarean delivery more often for their selfishness. In case of vaginal delivery the pregnant women can be discharged from hospitals in one or two days. But the surgeons for their selfishness, they prefer for caesarean deliveries. In caesarean delivery, the anesthesia is injected directly into the sac that surrounds the spinal cord, thus numbing the lower part of the body. It leads the maternal women to stay in the hospitals for more than four days and also takes a minimum of four months to recover from the issues in the surgery.

Data Source

The database contains 4043 records of deliveries that occurred between December 1, 2015 to December 31, 2017, at the Government and Private Hospitals, Primary Health Centre and Public (GPP). The study is conducted through a questionnaire, which included pregnant women who were delivered through cesarean or vaginal births. Data is collected by face-to-face interviews and self reporting questionnaires.

Measures

In this study, the mode of birth data is collapsed to a binary variable (Vaginal Birth and Cesarean Section). In the self-reported questionnaire, mothers are asked a series of questions regarding the situations about the pregnancy and birth.

These questions include whether they had taken prescribed medication such as antibiotics, blood pressure tablets, thyroid or any other medicines during pregnancy and whether the pregnancy has been complex by hypertension or diabetes. All questions were answered with ‘yes’ or ‘no’ responses. Data regarding the medication used in pregnancy were collected during the face-to-face interview with the mother. Maternal mental health is evaluated by enquiring with the mothers with a common question that, whether they underwent stress, anxiety or depression?

Method

Initially, the collected datasets are converted to binary values and are imported in excel, which is CSV file format. The correlated attributes are identified for finding the hidden pattern for the problem stated. Decision tree methods have been widely examined by existing works and presented interesting results.[26,27] The effectiveness of the J48 decision tree algorithm can be improved by performing a fine tuning of the given parameters.[28] The data miner tool has supported many inbuilt learning algorithms for correlated attributes. Among the various filtered tools, cfsSubsetEval, is chosen for this analysis. In order to describe the risk factors associated with C-section, decision tree via J48 algorithm is used.

Outcomes

In this study, the mode of birth is coded as CS and vaginal birth. The study is limited to only the women who delivered in the surveyed region.

Among 4043 women 2491 gave birth by CS and 1552 gave birth by vaginal. Among 35 variables in the database, the variables like maternal height, gestation age, fetus weight and presentation, amniotic fluid in the uterus, arrest of labor, stress or anxiety and taking medications during pregnancy lead to cesarean section. The delivery outcomes of private and government hospitals are compared and found that the majority of cesarean sections are performed in the private hospitals.

To predict this type of delivery through pregnancy characteristics, DM classification algorithms are persuaded. This classification algorithm processes a training set containing a group of attributes in order to discover relationships between the attributes that would make it possible to predict the outcome.

III. RESULTS

The overall rate of cesarean delivery of our practice is 61.61% and the attributes taken for the dataset are represented in Table 1.

Table 1: Attributes of Dataset

S. No.	Attribute
1	Family Type
2	Blood Group
3	Age
4	Delivery Type
5	Labor Pain at Delivery Time
6	No. of Babies
7	Height
8	Water Level at delivery Time
9	Child Wt
10	Hospital Type
11	Job
12	Job Type
13	Work
14	Work Type
15	Exercise
16	Bleeding
17	Habit of Eating
18	BP
19	Sugar
20	Thyroid
21	Any Other Diseases
22	Monthly Checkup
23	Healthy Fruits
24	Doctors Prescription
25	HB
26	Regular Periods
27	First Approach to Doctor
28	Any Abortion
29	Salt
30	Swelling of Legs
31	Vaccine
32	Folic Acid Tablet
33	Weight during 9^{th} Month

The database consists of 33 attributes, from which 15 attributes are selected based on cfsSubsetEval filter tool. All attributes are correlated based on the rank. The attributes selected for analyzing this research are shown in Table 2.

Table 2: Selected attributes for analysis

Selected Attributes
Hospital Type
Job Type
Work Type
Child Wt
Water Level at delivery time
Height
Age
Delivery Type
No. of Babies
Labor Pain at Delivery Time
HB
BP
Thyroid

Sugar

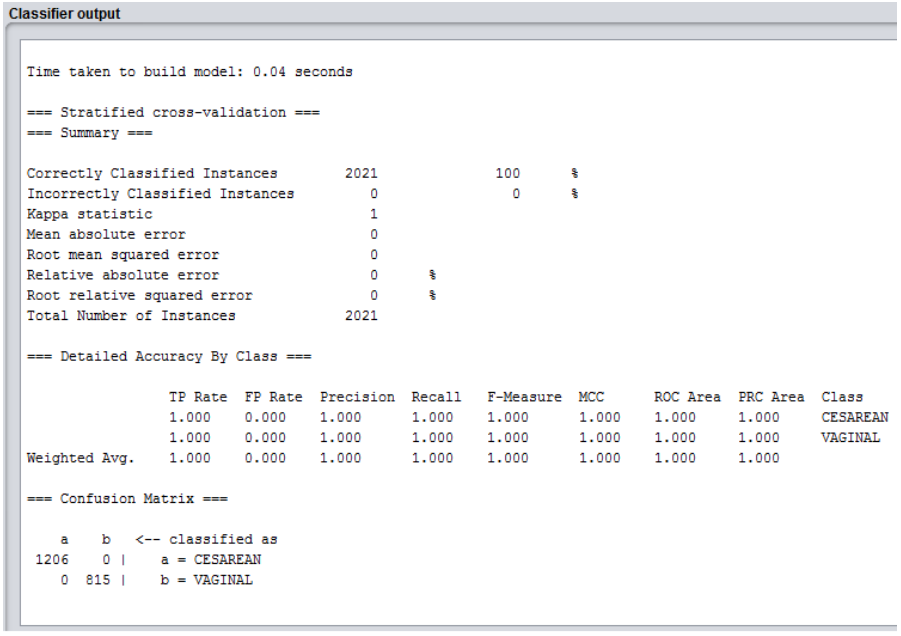
The main attributes used for predicting the type of delivery are listed in Table 3. The table shows the expected results for the attributes with high possible values. As per the opinion and findings of medical practitioners, while analyzing the data for classification for predicting the delivery type based on the target values of the class variable.

It is a two step-model. The first step is the division of data into training set used for predicting relations and testing set used for assessing the strength and accuracy of the relations predicted. In the next step, training set is used to build the Classifier Model and the testing set is used to validate the model built (Supplementary material). In this study, the goal is to classify the mode of delivery as vaginal or cesarean, based on the known attributes. Our study makes use of the decision tree model to predict the risk factors that are associated with cesarean delivery. Training the data included splitting the data into classes based on the class attribute value. The class attribute values in our cases are vaginal or cesarean. Decision tree method is used to identify the correct combination of the components and also helpful for identifying the type of delivery by analyzing the patient's medical records. Based on this, the final class values can be predicted as the final step. In our system, the user inputs values of all the 15 parameters. This input values are Boolean values. They are 0's and 1's. Here 0 denotes the positive value and 1 denotes the negative value. Processing is done internally for converting the input to categories. After processing, the predictor determines whether a normal delivery is possible or not. Results for both the algorithms are finally displayed, which is the categorization for the mode of delivery.

Table 3: Main attributes for predicting the delivery type

Attributes											
Age	Height	Weight	BP	HB	Thyroid	Amniotic Fluid	Hospital	Child Weight	No. of Babies	**Class Label**	**Delivery Type**
0	0	1	0	1	0	1	1	0	0	**4**	**Cesarean**
0	0	0	0	0	0	0	0	0	0	**0**	**Normal**
1	0	0	0	1	0	1	1	0	0	**4**	**Cesarean**
0	1	0	1	1	0	0	1	0	0	**4**	**Cesarean**
0	0	0	0	1	0	1	1	0	1	**4**	**Cesarean**
1	0	0	0	0	0	0	1	0	0	**2**	**Normal**
0	0	1	0	1	0	0	0	1	0	**3**	**Cesarean**
1	0	1	0	0	1	0	1	0	0	**4**	**Cesarean**
0	1	0	1	0	0	1	0	1	0	**4**	**Cesarean**
0	0	1	1	1	0	1	1	0	0	**5**	**Cesarean**

In a total of 4043 records, 50% of the data (2021) is used to develop the training model. It has been found that 1206 cases were cesarean and 815 were vaginal which are outlined in Fig 1.



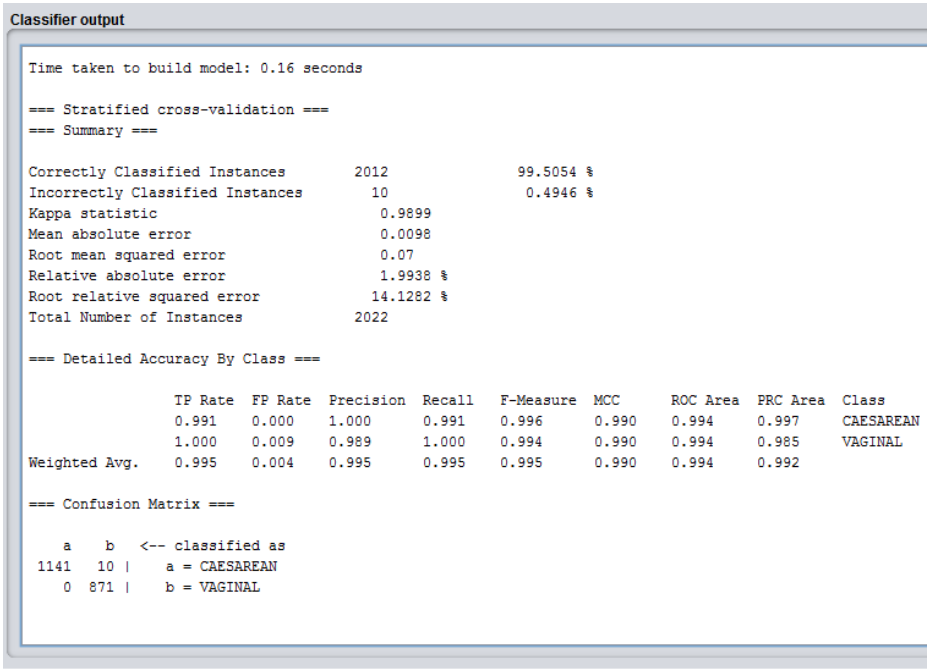
Classifier output

```
Time taken to build model: 0.04 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances        2021               100      %
Incorrectly Classified Instances         0                 0      %
Kappa statistic                          1
Mean absolute error                      0
Root mean squared error                  0
Relative absolute error                  0      %
Root relative squared error              0      %
Total Number of Instances             2021

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 1.000    0.000    1.000      1.000    1.000      1.000    1.000     1.000     CESAREAN
                 1.000    0.000    1.000      1.000    1.000      1.000    1.000     1.000     VAGINAL
Weighted Avg.    1.000    0.000    1.000      1.000    1.000      1.000    1.000     1.000

=== Confusion Matrix ===

    a    b   <-- classified as
 1206    0 |    a = CESAREAN
    0  815 |    b = VAGINAL
```

Fig. 1 Classifier Performance of Training Datasets

The remaining 50% data (2022) is tested using the developed model. Among the data used for testing, 2012 are correctly classified and obtained 1141 as cesarean delivery and 871 as vaginal delivery which are outlined in Fig 2. Fig 3 shows the main factors associated with cesarean delivery.

Based on the result, it is summarized as 793 women had attempted cesarean due to arrest of labor, 197 due to decreased amniotic fluid in the uterus, 61 due to multiple pregnancies, 47 due to HBP, 38 due to child weight above 3.5 kg and 5 due to age greater than 30. Some other factors associated with cesarean delivery are medications, height, fetal presentation, previous cesarean delivery, obesity, sleep disturbance and hypertension.



Classifier output

```
Time taken to build model: 0.16 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances        2012               99.5054 %
Incorrectly Classified Instances        10                0.4946 %
Kappa statistic                          0.9899
Mean absolute error                      0.0098
Root mean squared error                  0.07
Relative absolute error                  1.9938 %
Root relative squared error             14.1282 %
Total Number of Instances             2022

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.991    0.000    1.000      0.991    0.996      0.990    0.994     0.997     CAESAREAN
                 1.000    0.009    0.989      1.000    0.994      0.990    0.994     0.985     VAGINAL
Weighted Avg.    0.995    0.004    0.995      0.995    0.995      0.990    0.994     0.992

=== Confusion Matrix ===

    a    b   <-- classified as
 1141   10 |    a = CAESAREAN
    0  871 |    b = VAGINAL
```

Fig. 2 Classifier Performance of Testing Datasets

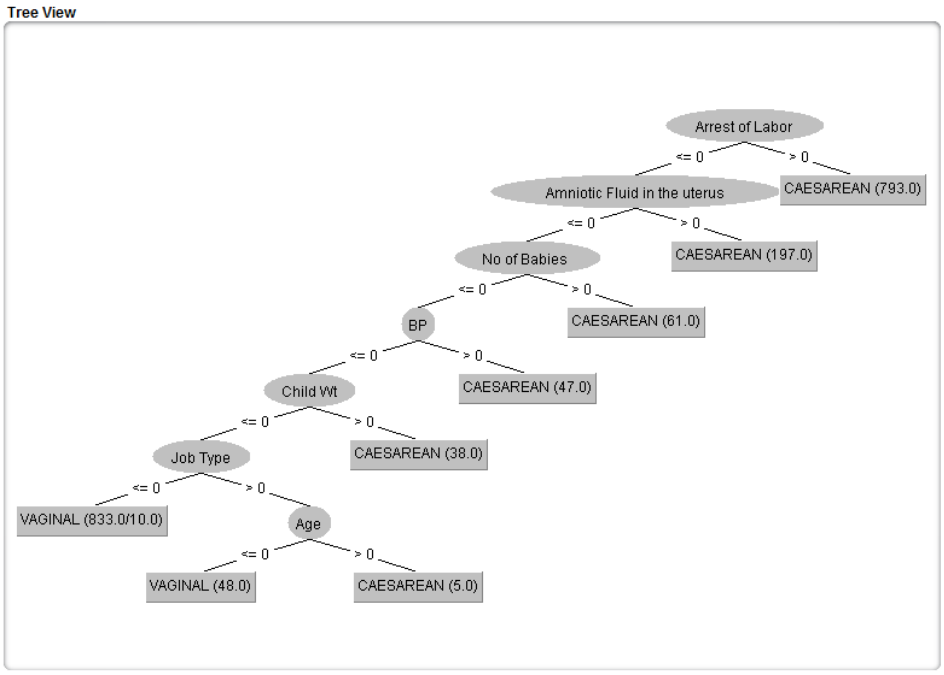


Fig. 3 Decision Tree via J48

IV. DISCUSSION

The database is implemented through data miner tool in exploration mode using decision tree method. In this work, there are two classes, so 2X2 Confusion Matrix is formed. In Confusion Matrix, the sum of diagonals represents the number of correctly classified instances and others are incorrectly classified instances. The stratified cross validation summary is given in Table 4, where Kappa Statistic is a measurement that compares the observed accuracy and expected accuracy. The increasing of Kappa Statistic value indicates the accuracy of classification. Decision tree method is the best for predicting the mode of delivery on Maternal Care Domain. The target of this work is to reduce the cesarean delivery, which is above 60% of the dataset, as per the Confusion Matrix.

As per gynecologist suggestion, if any of the seven attributes become abnormal that would certainly leads to do a cesarean and a doctor can easily predict the risk factors associated in delivery from these attributes. If the abnormal attributes change, the risk factors transform into normal attributes, which is achieved through the decision tree model.

Table 4: Stratified cross-validation

Classification Algorithm	Correctly Classified Instances	Incorrectly Classified Instances	Kappa statistic	Mean absolute error	Root mean squared error	Relative absolute error	Root relative squared error	Total No. of Instances
J48	2012	10	0.9899	0.0098	0.07	1.9938 %	14.1282 %	2022

V. CONCLUSION

Data mining techniques are applied in the health care domain, by which the women can benefit for their lives. This research found the meaningful hidden pattern from the real data set collected from the women, who had given birth in the past two years. Although, cesarean deliveries are common but they are generally safe in the face of high risks in delivering a baby vaginally. For this reason, cesarean delivery can be recommended.

Cesarean delivery is a major surgery and there is a greater risk for complications, including blood loss, organ damage and allergic reaction to anesthesia, infections, possible damage to other organs nearby, such as the bladder and blood clots. So it is the primary duty of the hospitals to provide awareness about vaginal deliveries instead of cesarean deliveries by way of medical camps and documentary films. Through this predicting classifier model, the cesarean delivery can be converted to normal delivery. The gynecologist can use this predicting model to analyze the patient's status and identify the risks easily. It is a huge socially relevant problem. Using real data from GPP, it is possible to prove the viability of using DM models to predict which

type of delivery should be pursued through the pregnancy characteristics of the women. Decision tree model provides satisfactory results with approximately 99.50% of sensitivity allowing the prediction of cesarean and vaginal delivery.

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