Constructing Birth Weight Prediction Model Based on Maternal Determinate in Ethiopia Using Ensemble Machine Learning Algorithm

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Introduction

- Birth weight is the primary weight of the newborn infant.
- The chance of the infant to outlive, healthy growth, and advancement was highly decided by birth weight.
- It is an important health indicator of the maternal and infant that affects the infant and indicates the past and present health status of the mothers.
- It is classified into three groups, Low birth weight < 2.5 kg, normal birth weight ≥2.5 kg < 4.0 kg, and macrosomia ≥ 4.0 kg.
- LBW and macrosomia are named abnormal birth weight and important predictors of a child's development and neonatal short and long-term health consequences.
- A child born with less than 2.5 kg needs extra hospital care, and there are standard alerts and instability over the future well-being results of infants.
- A child born with ≥ 4 kg is associated with negative maternal and neonatal outcomes.
- It is associated with complex deliveries, and obesity epidemics, with related problems during childhood, adolescence, and adulthood and abnormality during delivery.
- ABW may cause the current and future burden of chronic diseases for infants, Negatively affecting individuals, families, healthcare systems, and societies.
- There is a variation in the prevalence of ABW across countries, regions, and low and middle-income countries.
- The prevalence of LBW across the world covers 15.5 percent of infants and high birth weight influences 3-15 percent of all pregnancies
- Over 20 million infants in the world are born per year with low birth weights 17 percent in the developing and 6 percent in the developed world.
- The prevalence of LBW in sub-Saharan countries estimates to be 13 to 15 percent
- In the developed world the prevalence of HBW is ranging from 5 to 20 percent of all births
- In Ethiopia, there's a difference within the prevalence of ABW in several geographical areas with a variety from 12 to 17 percent (LBW) and 7 to 19.1 percent (macrosomia)
- It is a growing problem in most developing countries, like Ethiopia and it directly or indirectly contributes to psychological disorders, morbidity, mortality, and disability
- It leads to the economic and social burden
- In order to come up with feasible intervention strategies machine learning play a vital role
- In this study, we explore the potential applicability of homogenous ensemble learning techniques, python-based framework (flask), and Heroku-based cloud computing platform

Related Work

- A study conducted by [22][23], is targeted to find risk factors for abnormal birth weight (macrosomia), maternal and neonatal complications of fetal macrosomia, and its risk factor.
- The researcher undertook a case-control based on maternal and neonatal wards and the researcher include demographic and clinical detail in Tanzania with a cross-sectional analytical-based study in a health facility to assess the risk factor of abnormal birth weight and data was analyzed using statistical tools.
- The data were analyzed using multinomial logistic regression and a frequency, was used to relative risk ratio, and a 95 percent confidence interval was used to identify independent predictors of the abnormal weight of neonatal.
- Underestimate and/or overestimate the prevalence of abnormal weight.
- Most of the previous studies used local clinical data that covered limited geographical areas like a single city or town only with a small data set.
- These studies did not include features, such as history of birth, history of abortion, history of place of delivery, and history of malaria.
- The factors that contribute to the presence of abnormal birth weight weren't thoroughly studied.
- A study done by [1][24][24] aimed to apply one of the machine learning techniques and logistic regression with data mining techniques to spot important predictor variables to classify and predict abnormal weight.
- The researchers in [24]conduct the prediction of the birth weight of newborns using tensor flow end-to-end machine learning techniques using a deep neural network model in a Google cloud environment.
- The researcher in [15] conducted the application of ensemble learning to improve the prediction of fetal abnormal birth weight (macrosomia) and large for gestational age from prenatal ultrasound imaging measurements.
- The research conducted by [15][14] aimed to develop new predictive models that supported the medical records of pregnant women in Japan's urban hospitals.
- Furthermore, [14][15] and [16] aimed to construct a predictive model, but they did not identify the possible risk factors that result in abnormal birth weight, and extract rules which are important to make evidence-based strategies, policies, and interventions towards preventing and/or reducing the presence of abnormal birth weight in Ethiopia.
- This study, hence, is motivated to fill these gaps by constructing a multi-class predictive model, identifying risk factors, extracting useful rules, designing an innovative artifact, and deploying the predictive model for potential users using Heroku–based cloud computing platform.

Research Question

- What are the determinants attributes that influence the presence of abnormal birth weight in Ethiopia?
- Which homogenous ensemble machine learning technique is more appropriate to construct a model to predict birth weight?
- What are the useful rules generated from the multi-class predictive model based on the best-performed homogenous ensemble machine learning model?
- To what extent does the design artifact and deployed model predict birth weight?

Materials and Methods

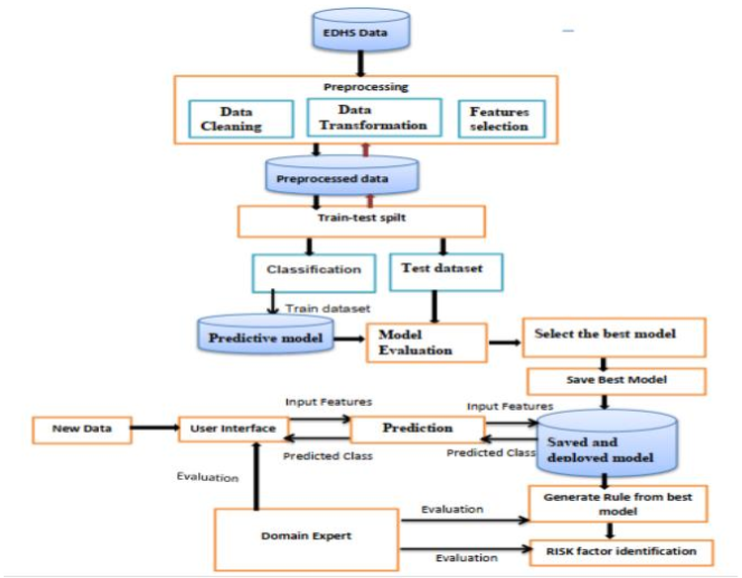

Figure 1. 1 Proposed model architecture

Experiment, Result, and Discussion

	filter feature selection			wrapper filter selection	
No	chi square	f_classif	mutual_I	SFs	RFE
1	v024	v013	v024	v013	v013
2	v025	v024	v106	v024	v024
3	v106	v025	v130	v027	v025
4.	v130	V106	v157	v106	v127
5.	v136	v130	bord	v130	v106
6.	v157	v136	b4	v136	v130
7	bord	v157	v218	v157	v136
8	b0	Bord	v228	bord	v157
9	b4	b0	v161	b0	bord
10	v218	b4	v453	b4	b4
11	hw57	V218	hw57	m1	v218
12	v445	hw57	h32a	v228	m1
13.	v161	v113	v223	m17	v161
14.	s1007c	s1007c	v166	hw57	v501
accuracy	71%	79%	70%	83.9%	69%

Figure 2. 2 Feature selection

Experiment, Result, and Discussion

RQ 1: Which homogenous ensemble machine learning technique is more appropriate to construct a model to predict birth weight?

No	Algorithm	Accuracy	Precision	Recall	F1_score	ROC-AUC	Cross-validation
1.	Random Forest	82.2%	80%	79.9%	79.9%	97.7%	87.4%
2.	Bagged Decision Tree	87.2%	88.9%	82.6%	85.2%	99.6%	91.2%
3.	Extra Tree	**90.7%**	90.8%	88.3%	89.5%	**99.8%**	94.7%
4.	Catboost	80.1%	82.2%	72.6%	75.9%	99.2%	84.3%

Figure 3. 3 Result

Determinant risk factors

RQ 2: What are the determinants attributes that influences the presence of abnormal birth weight in Ethiopia?

Risk Factors	Low birth weight	Macrosomia	For both
Birth order number, abortion, mode of delivery, malaria, maternal-occupation, antenatal visits during pregnancy, frequency of reading newspaper, smoking_cigarettes, marital status	Birth order, abortion and mode of delivery	Antenatal visit during pregnancy, frequency of reading newspaper, smoking cigarettes, and marital status	Maternal malaria during pregnancy and maternal occupation

Figure 4. 4 Determinant risk factors

Generated rules

RQ 3: What are the useful rules generated from the multi-class predictive model based on the best performed homogenous ensemble machine learning model?

R1	If region is "Amhara", number of household is "4-6", number of tetanus injections during pregnancy is "two, birth order is "two", age is "25-29, education level is "primary", sex of child is "male", residency is "urban" then normal birth weight baby will be born.
R2	If region is "Amhara", number of household is "4-6", number of tetanus injections during pregnancy is "two, birth order is "two", age is "25-29, education level is "no education", child is twin is "single" then Macrosomic birth weight baby will be born.
R3	If region is "Addis ababa", reading newspaper is "Not at all", child is twin "Single", education level is "Primary ",birth order is "one", number of tetanus injections during pregnancy is "two", marital status is "Married", age is "25-29, religion is " orthodox ", body mass index is "normal weight", , number of household is "1-3",sex of child is "female" then low birth weight baby will be born.

Figure 5. 5 Generated rules

Generated rules

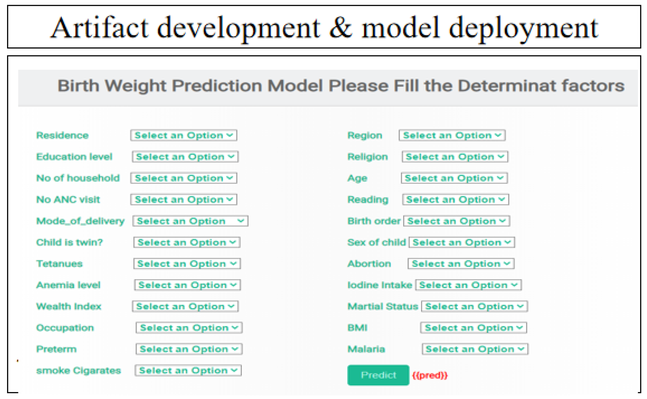

Figure 6. 6 Designed artifact

Conclusion

At the end of this conclusion, the researcher recommended that other researchers can do: v Design predictive models that include maternal determinates like chronic disease and genetic factors to predict birth weight in addition to socio-demographic factorsIdentifying the most determinant risk factors using fetal parameters with Socio-demographic factors using ensemble ML techniques

Recommendation

- The results of determinant risk factors for abnormal birth weight are identified
- The best appropriate homogenous ensemble machine learning algorithms is identified: Extra Tree with 90.7 percent accuracy and 76 percent domain expert acceptance
- Sample important rules are extracted using the best-performed algorithm
- Artifact is designed using the best-performed algorithm and the mode is deployed on the Heroku-cloud computing platform as a service

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