


RESEARCH ARTICLE

Open Access



Proposing a machine-learning based method to predict stillbirth before and during delivery and ranking the features: nationwide retrospective cross-sectional study

Toktam Khatibi^{1*} , Elham Hanifi¹, Mohammad Mehdi Sepehri¹ and Leila Allahqoli²

Abstract

Background: Stillbirth is defined as fetal loss in pregnancy beyond 28 weeks by WHO. In this study, a machine-learning based method is proposed to predict stillbirth from livebirth and discriminate stillbirth before and during delivery and rank the features.

Method: A two-step stack ensemble classifier is proposed for classifying the instances into stillbirth and livebirth at the first step and then, classifying stillbirth before delivery from stillbirth during the labor at the second step. The proposed SE has two consecutive layers including the same classifiers. The base classifiers in each layer are decision tree, Gradient boosting classifier, logistics regression, random forest and support vector machines which are trained independently and aggregated based on Vote boosting method. Moreover, a new feature ranking method is proposed in this study based on mean decrease accuracy, Gini Index and model coefficients to find high-ranked features.

Results: IMAN registry dataset is used in this study considering all births at or beyond 28th gestational week from 2016/04/01 to 2017/01/01 including 1,415,623 live birth and 5502 stillbirth cases. A combination of maternal demographic features, clinical history, fetal properties, delivery descriptors, environmental features, healthcare service provider descriptors and socio-demographic features are considered. The experimental results show that our proposed SE outperforms the compared classifiers with the average accuracy of 90%, sensitivity of 91%, specificity of 88%. The discrimination of the proposed SE is assessed and the average AUC of $\pm 95\%$, CI of $90.51\% \pm 1.08$ and $90\% \pm 1.12$ is obtained on training dataset for model development and test dataset for external validation, respectively. The proposed SE is calibrated using isotopic nonparametric calibration method with the score of 0.07. The process is repeated 10,000 times and AUC of SE classifiers using random different training datasets as null distribution. The obtained *p*-value to assess the specificity of the proposed SE is 0.0126 which shows the significance of the proposed SE.

(Continued on next page)

* Correspondence: toktam.khatibi@modares.ac.ir

¹School of Industrial and Systems Engineering, Tarbiat Modares University (TMU), Tehran 14117-13114, Iran

Full list of author information is available at the end of the article



© The Author(s). 2021 **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.