

Document details

[Back to results](#) | 1 of 132 [Next >](#)[View at Publisher](#) |  | [Export](#) | [Download](#) | [Add to List](#) | [More...](#)

Computational and Structural Biotechnology Journal

Volume 15, 2017, Pages 26-47

[Open Access](#)**Heart Failure: Diagnosis, Severity Estimation and Prediction of Adverse Events Through Machine Learning Techniques** (Review)Tripoliti, E.E.^{ab}, Papadopoulos, T.G.^a, Karanasiou, G.S.^{ab}, Naka, K.K.^{cd}, Fotiadis, D.I.^{ab}^a Department of Biomedical Research, Institute of Molecular Biology and Biotechnology, FORTH, Ioannina, Greece^b Unit of Medical Technology and Intelligent Information Systems, University of Ioannina, Ioannina, Greece^c Michaelidion Cardiac Center, University of Ioannina, Ioannina, Greece[View additional affiliations](#)[View references \(69\)](#)

Abstract

Heart failure is a serious condition with high prevalence (about 2% in the adult population in developed countries, and more than 8% in patients older than 75 years). About 3–5% of hospital admissions are linked with heart failure incidents. Heart failure is the first cause of admission by healthcare professionals in their clinical practice. The costs are very high, reaching up to 2% of the total health costs in the developed countries. Building an effective disease management strategy requires analysis of large amount of data, early detection of the disease, assessment of the severity and early prediction of adverse events. This will inhibit the progression of the disease, will improve the quality of life of the patients and will reduce the associated medical costs. Toward this direction machine learning techniques have been employed. The aim of this paper is to present the state-of-the-art of the machine learning methodologies applied for the assessment of heart failure. More specifically, models predicting the presence, estimating the subtype, assessing the severity of heart failure and predicting the presence of adverse events, such as destabilizations, re-hospitalizations, and mortality are presented. According to the authors' knowledge, it is the first time that such a comprehensive review, focusing on all aspects of the management of heart failure, is presented. © 2016 The Authors

Author keywords

Classification; Data mining; Diagnosis; Heart failure; Prediction; Severity estimation

Indexed keywords

Engineering controlled terms: Artificial intelligence; Cardiology; Classification (of information); Computer aided diagnosis; Costs; Data mining; Diagnosis; Forecasting; Heart; Learning algorithms

Clinical practices; Developed countries; Disease management strategies; Estimation and predictions; Health care professionals; Heart failure; Hospital admissions; Machine learning techniques

Engineering main heading: Learning systemsISSN: 20010370 **Source Type:** Journal **Original language:** EnglishDOI: 10.1016/j.csbj.2016.11.001 **Document Type:** Review**Publisher:** Elsevier B.V.

References (69)

[View in search results format](#) All [Export](#) | [Print](#) | [E-mail](#) | [Create bibliography](#) Ponikowski, P., Voors, A.A., Anker, S.D., Bueno, H., Cleland, J.G.F., Coats, A.J.S., Falk, V., (...), Van Der Meer, P.1 [2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure](#)(2016) *European Heart Journal*, 37 (27), pp. 2129-2200m. [Cited 118 times](#).<http://eurheartj.oxfordjournals.org/>

doi: 10.1093/eurheartj/ehw128

[View at Publisher](#) |  Aljaaf, A.J., Al-Jumeily, D., Hussain, A.J., Dawson, T., Fergus, P., Al-Jumaily, M.2 Predicting the likelihood of heart failure with a multi level risk assessment using decision tree (2015) *Third international conference on technological advances in electrical, Beirut, Lebanon* Cowie, M.R.3 The heart failure epidemic (2012) *Medicographia*. [Cited 2 times](#). Son, C.-S., Kim, Y.-N., Kim, H.-S., Park, H.-S., Kim, M.-S.4 [Decision-making model for early diagnosis of congestive heart failure using rough set and decision tree approaches](#)

Cited by 0 documents

Inform me when this document is cited in Scopus:

[Set citation alert](#) | [Set citation feed](#)

Related documents

[Generalized discriminant analysis for congestive heart failure risk assessment based on long-term heart rate variability](#)
Shahbazi, F., Asl, B.M.
(2015) *Computer Methods and Programs in Biomedicine*

[Classification tree for risk assessment in patients suffering from congestive heart failure via long-term heart rate variability](#)
Mellilo, P., De Luca, N., Bracale, M.
(2013) *IEEE Journal of Biomedical and Health Informatics*

[Heart rate variability for automatic assessment of congestive heart failure severity](#)
Mellilo, P., Pacifici, E., Orrico, A.
(2014) *IFMBE Proceedings*

[View all related documents based on references](#)

Find more related documents in Scopus based on:

[Authors](#) | [Keywords](#)

Metrics


5 Mendeley Readers 50TH PERCENTILE

1 Tweet

[Select data provided by altmetric.com](#)[View all metrics](#)

(2012) *Journal of Biomedical Informatics*, 45 (5), pp. 999-1008. Cited 19 times.

doi: 10.1016/j.jbi.2012.04.013

View at Publisher 


Roger, V.L.

5 **The heart failure epidemic**

(2010) *International Journal of Environmental Research and Public Health*, 7 (4), pp. 1807-1830. Cited 50 times.

<http://www.mdpi.com/1660-4601/7/4/1807/pdf>

doi: 10.3390/ijerph7041807


View at Publisher 

Dickstein, K., Cohen-Solal, A., Filippatos, G., McMurray, J.J.V., Ponikowski, P., Poole-Wilson, P.A., Strömberg, A., (...), Zannad, F.

6 **ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2008**

(2008) *European Heart Journal*, 29 (19), pp. 2388-2442. Cited 2247 times.

doi: 10.1093/eurheartj/ehn309

View at Publisher 

Asyali, M.H.


7 **Discrimination power of long-term heart rate variability measures (2003)**

İşler, Y., Kuntalp, M.

8 **Combining classical HRV indices with wavelet entropy measures improves to performance in diagnosing congestive heart failure**

(2007) *Computers in Biology and Medicine*, 37 (10), pp. 1502-1510. Cited 69 times.

doi: 10.1016/j.combiomed.2007.01.012

View at Publisher 

Thuraisingham, R.A.

9 **A classification system to detect congestive heart failure using second-order difference plot of RR intervals (2009) *Cardiol Res Pract.* Cited 16 times. (Article ID 807379)**

Elfadil, N., Ibrahim, I.


10 **Self organizing neural network approach for identification of patients with congestive heart failure (2011)**

Pecchia, L., Melillo, P., Sansone, M., Bracale, M.

11 **Discrimination power of short-term heart rate variability measures for CHF assessment**

(2011) *IEEE Transactions on Information Technology in Biomedicine*, 15 (1), art. no. 5634118, pp. 40-46. Cited 47 times.

doi: 10.1109/TITB.2010.2091647

View at Publisher 

Melillo, P., Fusco, R., Sansone, M., Bracale, M., Pecchia, L.

12 **Discrimination power of long-term heart rate variability measures for chronic heart failure detection**

(2011) *Medical and Biological Engineering and Computing*, 49 (1), pp. 67-74. Cited 36 times.

doi: 10.1007/s11517-010-0728-5


View at Publisher 

Jovic, A., Bogunovic, N.

13 **Electrocardiogram analysis using a combination of statistical, geometric, and nonlinear heart rate variability features**

(2011) *Artificial Intelligence in Medicine*, 51 (3), pp. 175-186. Cited 36 times.

doi: 10.1016/j.artmed.2010.09.005


View at Publisher 

Yu, S.-N., Lee, M.-Y.

14 **Conditional mutual information-based feature selection for congestive heart failure recognition using heart rate variability**

(2012) *Computer Methods and Programs in Biomedicine*, 108 (1), pp. 299-309. Cited 15 times.

doi: 10.1016/j.cmpb.2011.12.015


View at Publisher 

Yu, S.-N., Lee, M.-Y.

15 **Bispectral analysis and genetic algorithm for congestive heart failure recognition based on heart rate variability**

(2012) *Computers in Biology and Medicine*, 42 (8), pp. 816-825. Cited 18 times.

doi: 10.1016/j.combiomed.2012.06.005

View at Publisher 


Liu, G., Wang, L., Wang, Q., Zhou, G., Wang, Y., Jiang, Q.

16 **A new approach to detect congestive heart failure using short-term heart rate variability measures**

(2014) *PLoS ONE*, 9 (4), art. no. e93399. Cited 10 times.

<http://www.plosone.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.pone.0093399&representation=PDF>

doi: 10.1371/journal.pone.0093399


View at Publisher 

Narin, A., Isler, Y., Ozer, M.

17 **Investigating the performance improvement of HRV indices in CHF using feature selection methods based on backward elimination and statistical significance**

(2014) *Computers in Biology and Medicine*, 45 (1), pp. 72-79. Cited 10 times.

doi: 10.1016/j.combiomed.2013.11.016

View at Publisher 

Heinze, C., Trutschel, D.S.U., Golz, M.

18 **Discrimination and relevance determination of heart rate variability features for the identification of congestive heart failure**

(2014) *Proceedings of the 8th conference of the European study group on cardiovascular oscillations (ESGCO 2014)*


Yang, G., Ren, Y., Pan, Q., Ning, G., Gong, S., Cai, G., Zhang, Z., (...), Yan, J.

19 **A heart failure diagnosis model based on support vector machine**

(2010) *Proceedings - 2010 3rd International Conference on Biomedical Engineering and Informatics, BMEI 2010*, 3, art. no. 5639619, pp. 1105-1108. Cited 6 times.

ISBN: 978-142446496-8

doi: 10.1109/BMEI.2010.5639619

View at Publisher 

Gharehchopogh, F.S., Khalifelu, Z.A.

20 **Neural network application in diagnosis of patient: a case study, Abbottabad (2011)**


Masetic, Z., Subasi, A.

21 **Congestive heart failure detection using random forest classifier**

(2016) *Computer Methods and Programs in Biomedicine*, 130, pp. 54-64. Cited 2 times.

www.elsevier.com/locate/cmpb


doi: 10.1016/j.cmpb.2016.03.020

View at Publisher 

Goldberger, A.L., Amaral, L.A., Glass, L., Hausdorff, J.M., Ivanov, P.C., Mark, R.G., Mietus, J.E., (...), Stanley, H.E.

22 **PhysioBank, PhysioToolkit, and PhysioNet: components of a new research resource for complex physiologic signals.**

(2000) *Circulation*, 101 (23), pp. E215-220. Cited 2947 times.


View at Publisher 

Wu, J., Roy, J., Stewart, W.F.

23 **Prediction modeling using EHR data: Challenges, strategies, and a comparison of machine learning approaches**

(2010) *Medical Care*, 48 (6 SUPPL.), pp. S106-S113. Cited 69 times.

doi: 10.1097/MLR.0b013e3181de9e17

View at Publisher 


Zheng, Y., Guo, X., Qin, J., Xiao, S.

24 **Computer-assisted diagnosis for chronic heart failure by the analysis of their cardiac reserve and heart sound characteristics**

(2015) *Computer Methods and Programs in Biomedicine*, 122 (3), pp. 372-383. Cited 2 times.

www.elsevier.com/locate/cmpb

doi: 10.1016/j.cmpb.2015.09.001

View at Publisher 


Alonso-Betanzos, A., Bolón-Canedo, V., Heyndrickx, G.R., Kerkhof, P.L.M.

25 **Exploring guidelines for classification of major heart failure subtypes by using machine learning**

(2015) *Clinical Medicine Insights: Cardiology*, 9, pp. 57-71. Cited 3 times.

http://www.la-press.com/redirect_file.php?fileId=6492&filename=4844-CMC-Exploring-Guidelines-for-Classification-of-Major-Heart-Failure-Subtype.pdf&fileType=pdf

doi: 10.4137/CMC.S18746


View at Publisher 

Austin, P.C., Tu, J.V., Ho, J.E., Levy, D., Lee, D.S.

26 **Using methods from the data-mining and machine-learning literature for disease classification and prediction: A case study examining classification of heart failure subtypes**

(2013) *Journal of Clinical Epidemiology*, 66 (4), pp. 398-407. Cited 38 times.

doi: 10.1016/j.jclinepi.2012.11.008

View at Publisher 


Isler, Y.

27 **Discrimination of systolic and diastolic dysfunctions using multi-layer perceptron in heart rate variability analysis**

(2016) *Computers in Biology and Medicine*, 76, pp. 113-119.

www.elsevier.com/locate/combiomed

doi: 10.1016/j.combiomed.2016.06.029

[View at Publisher](#) 


- Shah, S.J., Katz, D.H., Selvaraj, S., Burke, M.A., Yancy, C.W., Gheorghiane, M., Bonow, R.O., (...), Deo, R.C.

28 **Phenomapping for novel classification of heart failure with preserved ejection fraction**

(2015) *Circulation*, 131 (3), pp. 269-279. Cited 64 times.

<http://circ.ahajournals.org>


doi: 10.1161/CIRCULATIONAHA.114.010637

[View at Publisher](#) 

- Fleg, J.L., Pina, I.L., Balady, G.J., Chaitman, B.R., Flether, B., Lavie, C., Limacher, M.C., (...), Bazzarre, T.

29 **Assessment of functional capacity in clinical and research applications: An advisory from the committee on exercise, rehabilitation, and prevention, council on clinical cardiology, American Heart Association**

(2000) *Circulation*, 102 (13), pp. 1591-1597. Cited 178 times.

[View at Publisher](#) 

- Akinyokun, C.O., Obot, O.U., Uzoka, F.-M.E.

Application of neuro-fuzzy technology in medical diagnosis: case study of heart failure

(2009) *World congress on medical physics and biomedical engineering, September 7-12, 2009*, pp. 301-304.

O. Dössel W.C. Schlegel Springer Berlin Heidelberg Munich, Germany

- Guidi, G., Iadanza, E., Pettenati, M.C., Milli, M., Pavone, F., Gentili, G.B.

31 **Heart failure artificial intelligence-based computer aided diagnosis telecare system**

(2012) *Impact analysis of solutions for chronic disease prevention and management*, pp. 278-281.

M. Donnelly C. Paggetti C. Nugent M. Mokhtari Berlin Heidelberg Springer


- Guidi, G., Pettenati, M.C., Melillo, P., Iadanza, E.

32 **A machine learning system to improve heart failure patient assistance**

(2014) *IEEE Journal of Biomedical and Health Informatics*, 18 (6), art. no. 6851844, pp. 1750-1756. Cited 5 times.

<http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=6221020>

doi: 10.1109/JBHI.2014.2337752

[View at Publisher](#) 


- Guidi, G., Pollonini, L., Dacso, C.C., Iadanza, E.

33 **A multi-layer monitoring system for clinical management of Congestive Heart Failure**

(2015) *BMC Medical Informatics and Decision Making*, 15 (3), art. no. S5. Cited 2 times.

<http://www.biomedcentral.com/bmcmedinformdecismak/>

doi: 10.1186/1472-6947-15-S3-S5


[View at Publisher](#) 

- Panina, G., Khot, U.N., Nunziata, E., Cody, R.J., Binkley, P.F.

34 **Role of spectral measures of heart rate variability as markers of disease progression in patients with chronic congestive heart failure not treated with angiotensin-converting enzyme inhibitors**

(1996) *American Heart Journal*, 131 (1), pp. 153-157. Cited 40 times.


doi: 10.1016/S0002-8703(96)90064-2

[View at Publisher](#) 

- Mietus, J.E., Peng, C.-K., Henry, I., Goldsmith, R.L., Goldberger, A.L.

35 **The pNNx files: Re-examining a widely used heart rate variability measure**

(2002) *Heart*, 88 (4), pp. 378-380. Cited 109 times.


[View at Publisher](#) 

- Musialik-Lydka, A., Średniawa, B., Pasyk, S.

36 **Heart rate variability in heart failure**

(2003) *Kardiologia Polska*, 58 (1), pp. 10-16. Cited 29 times.

<http://www.kardiologiapolska.pl/>

[View at Publisher](#) 

- Arbolishvili, G.N., Mareev, V.Yu., Orlova, Ya.A., Belenkov, Yu.N.

37 **Heart rate variability in chronic heart failure and its role in prognosis of the disease**

(2006) *Kardiologiya*, 46 (12), pp. 4-11. Cited 15 times.



- Casolo, G.C., Stroder, P., Sulla, A., Chelucci, A., Freni, A., Zerauscheck, M.

38 **Heart rate variability and functional severity of congestive heart failure secondary to coronary artery disease**

(1995) *European Heart Journal*, 16 (3), pp. 360-367. Cited 67 times.




- Pecchia, L., Melillo, P., Bracale, M.

39

Remote health monitoring of heart failure with data mining via CART method on HRV features


(2011) *IEEE Transactions on Biomedical Engineering*, 58 (3 PART 2), pp. 800-804. Cited 46 times.
doi: 10.1109/TBME.2010.2092776

[View at Publisher](#) 

Melillo, P., De Luca, N., Bracale, M., Pecchia, L.

40 Classification tree for risk assessment in patients suffering from congestive heart failure via long-term heart rate variability

(2013) *IEEE Journal of Biomedical and Health Informatics*, 17 (3), pp. 727-733. Cited 29 times.
doi: 10.1109/JBHI.2013.2244902

[View at Publisher](#) 


Shahbazi, F., Asl, B.M.

41 Generalized discriminant analysis for congestive heart failure risk assessment based on long-term heart rate variability

(2015) *Computer Methods and Programs in Biomedicine*, 122 (2), pp. 191-198. Cited 2 times.

www.elsevier.com/locate/cmpb

doi: 10.1016/j.cmpb.2015.08.007


[View at Publisher](#) 

Oba, S., Sato, M.-A., Takemasa, I., Monden, M., Matsubara, K.-I., Ishii, S.

42 A Bayesian missing value estimation method for gene expression profile data

(2003) *Bioinformatics*, 19 (16), pp. 2088-2096. Cited 304 times.

doi: 10.1093/bioinformatics/btg287


[View at Publisher](#) 

Cortes, C., Vapnik, V.

43 Support-Vector Networks

(1995) *Machine Learning*, 20 (3), pp. 273-297. Cited 13554 times.

doi: 10.1023/A:1022627411141


[View at Publisher](#) 

Fluss, R., Faraggi, D., Reiser, B.

44 Estimation of the Youden Index and its associated cutoff point

(2005) *Biometrical Journal*, 47 (4), pp. 458-472. Cited 385 times.

doi: 10.1002/bimj.200410135

[View at Publisher](#) 


Sideris, C., Alshurafa, N., Pourhomayoun, M., Shahmohammadi, F., Samy, L., Sarrafzadeh, M.

45 A data-driven feature extraction framework for predicting the severity of condition of congestive heart failure patients

(2015) *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, 2015-November, art. no. 7318908, pp. 2534-2537.

ISBN: 978-142449271-8

doi: 10.1109/EMBC.2015.7318908


[View at Publisher](#) 

Ketchum, E.S., Levy, W.C.

46 Multivariate Risk Scores and Patient Outcomes in Advanced Heart Failure

(2011) *Congestive Heart Failure*, 17 (5), pp. 205-212. Cited 22 times.

doi: 10.1111/j.1751-7133.2011.00241.x

[View at Publisher](#) 


Peterson, P.N., Rumsfeld, J.S., Liang, L., Albert, N.M., Hernandez, A.F., Peterson, E.D., Fonarow,

G.C., (...), Masoudi, F.A.

47 A validated risk score for in-hospital mortality in patients with heart failure from the American heart association get with the guidelines program

(2010) *Circulation: Cardiovascular Quality and Outcomes*, 3 (1), pp. 25-32. Cited 92 times.

doi: 10.1161/CIRCOUTCOMES.109.854877

[View at Publisher](#) 

Levy, W.C., Mozaffarian, D., Linker, D.T., Sutradhar, S.C., Anker, S.D., Cropp, A.B., Anand, I., (...), Packer, M.

48 The Seattle Heart Failure Model: Prediction of survival in heart failure

(2006) *Circulation*, 113 (11), pp. 1424-1433. Cited 880 times.

doi: 10.1161/CIRCULATIONAHA.105.584102


[View at Publisher](#) 

Lee, D.S., Austin, P.C., Rouleau, J.L., Liu, P.P., Naimark, D., Tu, J.V.









49 Predicting Mortality among Patients Hospitalized for Heart Failure: Derivation and Validation of a Clinical Model

(2003) *Journal of the American Medical Association*, 290 (19), pp. 2581-2587. Cited 853 times.


doi: 10.1001/jama.290.19.2581









[View at Publisher](#) 

Philbin, E.F., DiSalvo, T.G.

- 50 **Prediction of hospital readmission for heart failure: Development of a simple risk score based on administrative data**
(1999) *Journal of the American College of Cardiology*, 33 (6), pp. 1560-1566. Cited 140 times.
doi: 10.1016/S0735-1097(99)00059-5
[View at Publisher](#) 
- Pocock, S.J., Wang, D., Pfeffer, M.A., Yusuf, S., McMurray, J.J.V., Swedberg, K.B., Östergren, J., (...), Granger, C.B.
51 **Predictors of mortality and morbidity in patients with chronic heart failure**
(2006) *European Heart Journal*, 27 (1), pp. 65-75. Cited 446 times.
doi: 10.1093/eurheartj/ehi555
[View at Publisher](#) 
- Candelieri, A., Conforti, D., Perticone, F., Sciacqua, A., Kawecka-Jaszcz, K., Styczkiewicz, K.
52 **Early detection of decompensation conditions in heart failure patients by knowledge discovery: The HEARTFAID approaches**
(2008) *Computers in Cardiology*, 35, art. no. 4749186, pp. 893-896. Cited 12 times.
ISBN: 1424437067; 978-142443706-1
doi: 10.1109/CIC.2008.4749186
[View at Publisher](#) 
- Candelieri, A., Conforti, D., Sciacqua, A., Perticone, F.
53 **Knowledge discovery approaches for early detection of decompensation conditions in heart failure patients**
(2009) *ISDA 2009 - 9th International Conference on Intelligent Systems Design and Applications*, art. no. 5364868, pp. 357-362. Cited 2 times.
ISBN: 978-076953872-3
doi: 10.1109/ISDA.2009.204
[View at Publisher](#) 
- Candelieri, A., Conforti, D.
54 **A hyper-solution framework for SVM classification: application for predicting destabilizations in chronic heart failure patients**
(2010) *Open Med Inform J*, 4, pp. 136-140.
- Zolfaghar, K., Meadem, N., Teredesai, A., Basu Roy, S., Si-Chi, C., Muckian, B.
55 **Big data solutions for predicting risk-of-readmission for congestive heart failure patients, IEEE International Conference on Big Data**
(2013)
- Vedomske, M.A., Brown, D.E., Harrison Jr., J.H.
56 **Random forests on ubiquitous data for heart failure 30-day readmissions prediction**
(2013) *Proceedings - 2013 12th International Conference on Machine Learning and Applications, ICMLA 2013*, 2, art. no. 6786145, pp. 415-421. Cited 6 times.
doi: 10.1109/ICMLA.2013.158
[View at Publisher](#) 
- Roy, S.B., Teredesai, A., Zolfaghar, K., Liu, R., Hazel, D., Newman, S., Marinez, A.
57 **Dynamic hierarchical classification for patient risk-of-readmission**
(2015) *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 2015-August, pp. 1691-1700. Cited 2 times.
ISBN: 978-145033664-2
doi: 10.1145/2783258.2788585
[View at Publisher](#) 
- Koulaouzidis, G., Iakovidis, D.K., Clark, A.L.
58 **Telemonitoring predicts in advance heart failure admissions**
(2016) *International Journal of Cardiology*, 216, pp. 78-84. Cited 2 times.
www.elsevier.com/locate/ijcard
doi: 10.1016/j.ijcard.2016.04.149
[View at Publisher](#) 
- Turgeman, L., May, J.H.
59 **A mixed-ensemble model for hospital readmission**
(2016) *Artificial Intelligence in Medicine*, 72, pp. 72-82.
www.elsevier.com/locate/artmed
doi: 10.1016/j.artmed.2016.08.005
[View at Publisher](#) 
- Kang, Y., McHugh, M.D., Chittams, J., Bowles, K.H.
60 **Utilizing home healthcare electronic health records for telehomecare patients with Heart failure: A decision tree approach to detect associations with rehospitalizations**
(2016) *CIN - Computers Informatics Nursing*, 34 (4), pp. 175-182. Cited 2 times.
<http://www.cinjournal.com>

doi: 10.1097/CIN.000000000000223

[View at Publisher](#) 

- Fonarow, G.C., Adams Jr., K.F., Abraham, W.T., Yancy, C.W., Boscardin, W.J.
- 61 **Risk stratification for in-hospital mortality in acutely decompensated heart failure: Classification and regression tree analysis**
(2005) *Journal of the American Medical Association*, 293 (5), pp. 572-580. Cited 886 times.
doi: 10.1001/jama.293.5.572
[View at Publisher](#) 
- Bohacik, J., Kambhampati, C., Davis, D.N., Cleland, J.G.F.
- 62 **Alternating decision tree applied to risk assessment of heart failure patients**
(2013) *J Inf Technol*, 6 (2), pp. 25-33.
- Bohacik, J., Matiasko, K., Benedikovic, M., Nedeljakova, I.
- 63 **Algorithmic model for risk assessment of heart failure patients**
(2015) *Proceedings of the 2015 IEEE 8th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, IDAACS 2015*, 1, art. no. 7340724, pp. 177-181.
ISBN: 978-146738361-5
doi: 10.1109/IDAACS.2015.7340724
[View at Publisher](#) 
- Panahiazar, M., Taslimitehrani, V., Pereira, N., Pathak, J.
- 64 **Using EHRs and Machine Learning for Heart Failure Survival Analysis**
(2015) *Studies in Health Technology and Informatics*, 216, pp. 40-44. Cited 7 times.
<http://www.iospress.nl/bookserie/studies-in-health-technology-and-informatics/>
ISBN: 978-161499563-0
doi: 10.3233/978-1-61499-564-7-40
[View at Publisher](#) 
- Taslimitehrani, V., Dong, G., Pereira, N.L., Panahiazar, M., Pathak, J.
- 65 **Developing EHR-driven heart failure risk prediction models using CPXR(Log) with the probabilistic loss function**
(2016) *Journal of Biomedical Informatics*, 60, pp. 260-269. Cited 4 times.
<http://www.elsevier.com/locate/ymbsi/2016/01/009>
doi: 10.1016/j.jbi.2016.01.009
[View at Publisher](#) 
- Austin, P.C., Lee, D.S., Steyerberg, E.W., Tu, J.V.
- 66 **Regression trees for predicting mortality in patients with cardiovascular disease: What improvement is achieved by using ensemble-based methods?**
(2012) *Biometrical Journal*, 54 (5), pp. 657-673. Cited 20 times.
doi: 10.1002/bimj.201100251
[View at Publisher](#) 
- Subramanian, D., Subramanian, V., Deswal, A., Mann, D.L.
- 67 **New predictive models of heart failure mortality using time-series measurements and ensemble models**
(2011) *Circulation: Heart Failure*, 4 (4), pp. 456-462. Cited 12 times.
doi: 10.1161/CIRCHEARTFAILURE.110.958496
[View at Publisher](#) 
- Ramírez, J., Monasterio, V., Mincholé, A., Llamedo, M., Lenis, G., Cygankiewicz, I., Bayés De Luna, A., (...), Pueyo, E.
- 68 **Automatic SVM classification of sudden cardiac death and pump failure death from autonomic and repolarization ECG markers**
(2015) *Journal of Electrocardiology*, 48 (4), art. no. 52034, pp. 551-557. Cited 5 times.
<http://www.elsevier.com/locate/jelectrocard>
doi: 10.1016/j.jelectrocard.2015.04.002
[View at Publisher](#) 
- Adams Jr., K.F., Fonarow, G.C., Emerman, C.L., LeJemtel, T.H., Costanzo, M.R., Abraham, W.T., Berkowitz, R.L., (...), Horton, D.P.
- 69 **Characteristics and outcomes of patients hospitalized for heart failure in the United States: Rationale, design, and preliminary observations from the first 100,000 cases in the Acute Decompensated Heart Failure National Registry (ADHERE)**
(2005) *American Heart Journal*, 149 (2), pp. 209-216. Cited 1069 times.
doi: 10.1016/j.ahj.2004.08.005
[View at Publisher](#) 

About Scopus

- [What is Scopus](#)
- [Content coverage](#)
- [Scopus blog](#)
- [Scopus API](#)
- [Privacy matters](#)

Language

- [日本語に切り替える](#)
- [切换到简体中文](#)
- [切换到繁體中文](#)

Customer Service

- [Help](#)
- [Live Chat](#)
- [Contact us](#)

ELSEVIER

[Terms and conditions](#) [Privacy policy](#)

Copyright © 2017 Elsevier B.V. All rights reserved. Scopus® is a registered trademark of Elsevier B.V.

Cookies are set by this site. To decline them or learn more, visit our [Cookies page](#).

