

# LiDS Newsletter

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## In Brief

### Upcoming LiDS Webinars

Mediation Analysis with Failure Time Outcomes  
by Linda Valeri, Columbia University  
Friday, March 3, 2023 at 9:30 a.m. ET

### 2023 LiDS Conference

May 31–June 2, 2023 in Raleigh, North Carolina

### LiDS Sessions at 2023 JSM

Three invited sessions  
Two topic-contributed sessions

### LiDS Statistics

722 members as of December 2022  
29% increase from December 2021

### Software Review

Win Ratio Regression Using the {WR} Package

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## LiDS Officers

Chair: Grace Y. Yi  
Chair-Elect: (Tony) Jianguo Sun  
Past Chair: Douglas E. Schaubel  
Admin. Officer 2022–2024: Sharon Xie  
Treasurer 2021–2023: Yu Cheng  
Program Chair (2023): Ying Ding  
Program Chair-Elect: Pamela A. Shaw  
Past Program Chair: Jing Ning  
COS Representative: Ronghui (Lily) Xu  
Webinar Committee Chair: Esra Kurum  
Webinar Committee Co-chair: Wenbo Wu  
Communications Officer: Wenjie Wang

## Chair’s Message



January 1, 2023 marks the beginning of my term as Chair of the LiDS section, and I am honoured to serve the Section in this role. I am immensely proud of the Section’s vivid activities, strong reputation, and steady growth since its establishment.

LiDS initially started as an ASA Interest Group (LiDA-IG) in November 2014 and became an official ASA section in 2018. Currently, the LiDS section has grown as a notable section of ASA, and has proudly attracted over 700 members. Undoubtedly, the achievements of the Section would not have

been possible without the enthusiastic support and participation of our members. I must take this moment to celebrate the hard work of so many volunteers who worked tirelessly behind the scenes over the past years. We are thankful to all the past executive members for their tremendous dedication to the Section. The Section would not have thrived without the remarkable leadership from all the former Chairs of LiDS. We are indebted to those who chaired LiDA-IG or LiDS since 2014, in order: Ross Prentice, Mei-Ling Lee, Jack Kalbfleisch, Mei-Cheng Wang, Richard Cook, Jianwen Cai, Nick Jewell, Mimi Kim, and Douglas Schaubel.

While we have all been going through this pandemic by undertaking increased workloads as well as facing new challenges in our personal lives, the Executive Committee has been dedicated to undertaking the Section’s business effectively. We pushed ahead despite massive roadblocks and accomplished so much. Due to the great effort of the Program Committee (chaired by Jing Ning), LiDS sponsored three invited sessions, two topic-contributed sessions, and one contributed session for the 2022 JSM, and co-sponsored three topic-contributed sessions and two contributed poster sessions. A Student Paper Award session was organized for the 2022 JSM thanks to the hard work from the Student Awards Committee (chaired by Haoda Fu). A big thank you is owed to the Webinar Committee (chaired by Esra Kurum) who organized two successful webinars and one short course in 2022, which attracted over 100 participants on average. The financial situation of the Section has been well looked after by the capable Treasurer, Yu Cheng, and the LiDS Newsletter has been carefully taken care of by Wenjie Wang (Communications Officer). Our affiliation with ASA and other sister sections has been under watch by the LiDS Representative to the ASA Council on Sections, Ronghui (Lily) Xu. The Administrative Officer, Sharon Xie, ensured that the Section ran properly.

Since taking the role of Chair-Elect on January 1, 2022, I have had the great pleasure and honour of working closely with the Executive Committee on the Section’s matters. I have witnessed and appreciated the wisdom, support, and dedication of the executive members during my past year of “Chair-Training”. I am particularly indebted to Mimi Kim and Douglas Schaubel who have offered me their valuable experience as the Section Chair. I wish I could stay in the same position and continue to work with them in the coming year. Sadly, Mimi left the Executive Committee as of January 1, 2023, after offering her dedicated leadership for a three-year cycle. Thank you, Mimi, for your wonderful leadership and dedicated service to LiDS! You will be missed! One thing that comforts me is that Doug will stay on the Executive Committee as Past-Chair in 2023, and I look forward to receiving Doug’s continued advice and contributions to the Section.

Additionally, sincere thanks are due to the departing executive member, Haoda Fu, who finished his role as Past Program Chair. Thank you for your valuable commitment to LiDS, Haoda! In the meantime, we welcome the newly elected members joining the Executive Committee — a heartfelt welcome to (Tony) Jianguo Sun (Chair-Elect) and Pam Shaw (Program Chair-Elect). A warm welcome is extended to Wenbo Wu who joined the LiDS Webinar Committee during 2022 and is now hard at work on the 2023 LiDS Conference.

Looking forward, we have much work to do. Preparations and projects are underway, guided by very capable hands. The LiDS Webinar Committee (chaired by Esra Kurum) is organizing online events for 2023. A coming short course, entitled “*Mediation Analysis with Failure Time Outcomes*”, to be given by Linda Valeri (Columbia University), has been scheduled for March 3, 2023. The Program Committee (chaired by Ying Ding) has organized invited and topic-contributed sessions for 2023 JSM, to be held on August 5–10, 2023 in Toronto.

Notably, the Section’s signature event will be highlighted in the coming 2023 LiDS conference, scheduled on May 31–June 2, 2023 in Raleigh, North Carolina at the Marriott City Center. Thanks to the tireless efforts and tremendous leadership of Doug Schaubel (Program Chair) and Mimi Kim (Program Co-Chair), the scientific sessions of the conference are in good shape. With the theme “*Making an impact in the data science era*”, the conference will feature two keynote talks by Per Andersen (University of Copenhagen) and Mei-Cheng Wang (Johns Hopkins), four short courses, and fifty-one invited sessions, including a student award winner session and a poster session. The scientific sessions will cover a broad range of topics concerning lifetime data analysis. The conference will also provide us with an opportunity to connect socially through an open mixer and a banquet. We owe a big thank you to the Local Organizing Committee, Shanshan Zhao (Chair), and Wenbin Lu (Co-Chair), who contributed countless hours looking after conference logistics to ensure an enjoyable experience in Raleigh.

While I have big shoes to fill and challenges may emerge unexpectedly, I believe that the solid work accomplished by the Section over the past years makes the Section immune to various obstacles. Meanwhile, new opportunities will help the Section continue to grow steadily. The Section will continue to undertake its mission to promote and support the development, application and appropriate use of statistical methods for design and analysis of lifetime data. I believe the key factor to the Section’s success is the strong support from our members. I look forward to your active participation in the Section’s activities and your help in promoting the reputation of LiDS. Please encourage your colleagues and students to become LiDS members. If you have ideas and thoughts about the Section, I would love to hear them.

Finally, I hope you and your loved ones continue to stay safe and healthy. I look forward to serving LiDS in the coming year.

*Grace Y. Yi*, Chair 2023

## Message from the Past Chair

Happy New Year, LiDS members!

This is an exciting time for the LiDS section! With the membership having increased by approximately 150 in 2022, the section now has over 700 members. This represents outstanding growth for a relatively new section. The LiDS webinar series

continues to put on excellent short courses, with Linda Valeri slated to give the next webinar, “*Mediation Analysis with Failure Time Outcomes*” on March 3, 2023. In addition, the 2023 Lifetime Data Science Conference is right around the corner (begins May 31), and promises to continue the tradition of exciting and stimulating LiDS conferences. Huge thanks are owed to Shanshan Zhao and Wenbin Lu who are Co-Chairing 2023 LiDS Conference Local Organizing Committee. This is a tremendous amount of work and Shanshan and Wenbin remain hard at work to ensure that the 2023 conference is as successful as the 2017 and 2019 conferences.



The Executive Committee is excited to welcome new members (Tony) Jianguo Sun (as Chair-Elect) from the University of Missouri; Pam Shaw (as Program Chair-Elect) from the Kaiser Permanente Washington Health Research Institute. In addition, Wenbo Wu (from New York University) has joined the EC and has the dual role of serving on Webinar Committee chaired by Esra Kurum as well as the challenging task of building the website for the 2023 LiDS Conference. Welcome Tony, Pam and Wenbo!

As the LiDS gods push the button for the proverbial trapped door and I fall into the abyss, the Section is fortunate to be left in the very capable hands of Grace Yi, our 2023 LiDS Chair. Grace is a Professor in the Department of Statistics and Actuarial Science at the University of Western Ontario, having spent the first 19 years of her career at the University of Waterloo. Grace’s numerous service accomplishments include founding the first chapter (the Canadian Chapter) of the International Chinese Statistical Association, and serving as President of the Statistical Society of Canada during 2020–2022. I’ve known Grace for years and I look forward to supporting what I know will be her productive and rewarding tenure as LiDS Chair. Welcome, Grace!

I truly enjoyed my time as LiDS Chair, mostly due to having fantastic support from such a committed and enthusiastic LiDS Executive Committee. I would like to thank Past-Chair (now unofficially the “Past-Past-Chair”) Mimi Kim for being an invaluable resource to me during the past year, and for always being an energetic contributor to the LiDS EC meetings. Mimi is now cycling off the LiDS EC, having served during 2020–2022 as Chair-Elect, Chair and Past-Chair. Haoda Fu is also completing his service to the LiDS EC, and we are grateful for his efforts to ensure a strong presence at the Joint Statistical Meetings as LiDS Program Chair-Elect, Program Chair and Past Program Chair. I would like to thank Sharon Xie for being so organized as the LiDS Administrative Officer and for dealing with my endless emails this past year. Esra Kurum has done an incredible job as the LiDS Webinar Committee Chair by recruiting top-tier speakers and hosting the events which consistently attract large audiences. LiDS is grateful to Rick Peterson of the ASA for all of his technical and administrative assistance with the LiDS webinars and several other LiDS activities. Ning Jing has done an amazing job as LiDS Program Chair, with the LiDS imprint on JSM becoming more prominent each year. Ying Ding now takes over as the 2023 Program Chair. Yu Cheng has done a great job managing the balance sheet as the LiDS treasurer. We thank Lily Xu for her hard work as the LiDS representative on the ASA Council on Sections. Finally, we thank Wenjie Wang for his

excellent work as the LiDS Communications Officer. Wenjie’s tasks are many and include maintaining the LiDS ASA website, as well as preparing the newsletter you are now reading.

Time flies. It was one year ago (almost to the hour) that I was drafting the Chair’s message. In fact, I was sitting in the same hockey rink, in exactly the same seat in the stands, watching my son (older son last year; younger son this year) practice for the Lower Merion Bulldogs. Time is increasingly valuable, and on behalf of the LiDS membership I thank the Executive Committee members, past and present, for dedicating their time and energy to making LiDS what has become.

In closing, I wish you all a happy and healthy 2023! I hope you renew your LiDS membership and encourage your colleagues to join. I look forward to “seeing” you at this year’s webinars and seeing you in Raleigh. Thank you for your past and continued support of the Lifetime Data Science Section!

*Douglas Schaubel, Chair 2022*

## 2023 Election Candidates



This year we have three positions open on the Executive Committee of the Section on Lifetime Data Science: Chair-Elect, Program Chair-Elect, and Treasurer. We are fortunate to have a strong slate of candidates who have agreed to stand for election. They are as follows:

### Chair-Elect

Zhezhen Jin (Columbia University, Mailman School of Public)  
Limin Peng (Emory University, Rollins School of Public Health)

### Program Chair-Elect

Mengling Liu (New York University, Grossman School of Medicine)  
Michael Pennell (Ohio State University, College of Public Health)

### Treasurer

Yifei Sun (Columbia University, Mailman School of Public Health)  
Chen Hu (Johns Hopkins University, Sidney Kimmel Comprehensive Cancer Center)

The American Statistical Association will handle the election process, and we will hear more about the candidates including their biographies and personal statements in the coming weeks. On behalf of the LiDS Committee on Nominations, comprised of Haoda Fu, Edsel Pena, and myself, we express thanks to section members for participating in the nomination process, and to the candidates for their commitment to the section and willingness to consider these leadership positions.

*Mimi Kim, Chair of Committee on Nominations*

## Report from the Administrative Officer

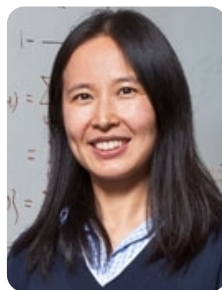
As of December 12, 2022, our section has a total of 722 members, which represents 29% increase compared to December 2021. Our official website is maintained by our communication officer, Wenjie Wang (email: [wang@wwenjie.org](mailto:wang@wwenjie.org)): its link is <https://community.amstat.org/lids/home/>.



The section’s 2022 annual meeting took place on August 8, 2022, during JSM at Washington DC. It was chaired by the section chair Douglas Schaubel. LiDS Executive Committee members presented during the annual meeting. The section congratulated its three new IMS fellows and one new ASA fellow.

*Sharon Xie, Administrative Officer 2022–2024*

## Treasurer’s Report



The balance by 12/31/2021 was \$43,010.64. Between January 1, 2022 to December 31, 2022, the LiDS offered three successful fee-based Webinars with an accumulated income of \$6,867.34 from the registration. The additional revenue of \$1,662 came from membership dues, interest, and dividends. The number is incomplete and expected to be slightly larger, as the ASA has yet closed their book for 2022. During this period, the LiDS spent \$3,000 on awards/plaques for student awardees presented at JSM and about \$1,700 to sponsor activities including the member business meeting and the first in-person gathering of the executive members. The current balance by December 31, 2022, is \$44,707.27. Please note that the ASA has not charged us the meeting overhead of \$1650 nor taken their share of the net profit from the webinars. The balance will likely be \$5,000 lower than what we have here once they tabulate all the expenses.

<b>Beginning Balance</b>	<b>12/31/2021</b>	<b>\$43,010.64</b>
<b>Income</b>		
Membership due, Alloc Int/Div		\$1,662.00
Registration	<b>11/30/2021</b>	\$6,867.34
Net share—CE/Conf/Proceedings		\$0.00
<b>Total Income</b>		<b>\$8,529.34</b>
<b>Expense</b>		
Honorarium		\$2,150.00
Meeting overhead		\$0.00
Bank/Paypal charges & credit card fees		\$14.18
Food function		\$1,362.00
AV equipment rental		\$306.53
Awards/Plaques		\$3,000.00
<b>Total Expense</b>		<b>\$6,832.71</b>
<b>Net Total Income</b>		<b>\$1,696.63</b>
<b>Ending Balance</b>	<b>12/31/2022</b>	<b>\$44,707.27</b>

*Yu Cheng, Treasurer 2021–2023*

## Report on Council of Sections

The ASA Council of Sections (COS) supports the goals and interests of the ASA’s sections that are consistent with those of the association. The COS encourages the development of sections, assists in the promotion of section activities, fosters

member involvement in functions of the association, and promotes communication and cooperation among the sections.



This year the COS Business Meeting at the 2022 JSM was held on Sunday, August 7. At the meeting overview of all sections were provided, where our Lifetime Data Science (LiDS) Section was shown to be the fastest growing (up 11% last year) in terms of membership, while some other sections were shrinking. The shrinking part might be a reflection of the overall ASA membership, with competition from other data science fields.

The Text Analytics Interest Group (IG) presented at the business meeting their petition to become a Section of ASA. The group had met all of the requirements for an Interest Group to become a Section: three years as an Interest Group with at least 50 members (established 2019), a petition of at least 200 full ASA members indicating they would support the new Section and pay dues, list of accomplishments as an Interest Group, and a proposed charter. A vote on chartering the new Section was taken in the fall, which was subsequently approved, and the new Section will be officially chartered on January 1, 2023. Meanwhile the leaders of the group met recently and decided they would prefer to change the name from the Section on Text “Analytics” to the Section on Text “Analysis.”

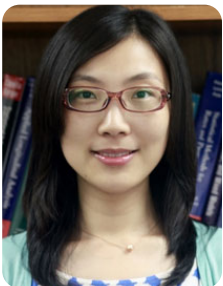
On October 17 meeting of the COB governing board (COSGB), a petition for a new interest group called Forensic Statistics was presented. The COSGB will consider and then vote on whether to approve the new IG.

*Ronghui (Lily) Xu, COS Representative*

## JSM 2023 Program Update

The 2023 Joint Statistical Meetings (JSM) will be held in Toronto, Canada, during August 5–10, 2023, with the theme “*One Community: Informing Decisions and Driving Discovery*”. LiDS is excited to sponsor the following three invited sessions:

1. Monday, August 7, 8:30–10:20 a.m. “Recent Advances in Survival Risk Prediction” (organizer: Kevin He);
2. Tuesday, August 8, 10:30–12:20 p.m. “The statistical analysis of complex time-to-event data” (organizer: Lu Mao);
3. Thursday, August 10, 10:30 a.m.–12:20 p.m. “Emerging lifetime data analysis methods based on non-conventional survival models” (organizer: Chenxi Li).



We also sponsor the following two topic-contributed sessions:

1. “LiDS Student Paper Award Presentations” (organizer: Jing Ning);
2. “Recent results on causal inference with survival data” (organizer: Ingrid Van Keilegom).

Thanks to all the session organizers for their support and participation. All speakers must submit abstracts and register for JSM by February 1, 2023, through the official JSM abstract submission system.

*Ying Ding, Program Chair 2023*

## 2023 LiDS Conference



The 2023 LiDS conference will be held May 31–June 2, 2023 in Raleigh, North Carolina at the Marriott City Center. The theme of the conference is “*Making an impact in the data science era*”, retained from the planned 2021 conference which was unfortunately postponed due to the pandemic. Following similar format of the successful conferences at the University of Pittsburgh in 2019 and at

the University of Connecticut in 2017, this conference features short courses and an opening mixer/poster session on May 31; two keynote talks and parallel sessions on June 1–2; and a banquet the evening of June 1. We are thrilled to have Mei-Cheng Wang from the Johns Hopkins University and Per Andersen from the University of Copenhagen as our keynote speakers! The short courses cover a wide range of topics, including causal inference approaches for time-to-event data (by Xiaofei Wang and Shu Yang); methods for the analysis of recurrent events (Jianwen Cai); prediction modeling with survival data (Michael Pencina); as well as models for multi-state, longitudinal and other complex data structures (by Michael Crowther). We will have 51 parallel invited scientific sessions on a wide variety of topics about lifetime data, including a session dedicated to the winners of our Student Paper Competition. We strongly encourage students to present their work in the poster competition, to be held during the opening mixer on May 31. A call for Student Paper Competition has been sent out, with a submission deadline of Feb 28, 2023. General registration will open soon. Please mark your calendar and watch for registration details. We look forward to meeting you in person at Raleigh!

*Shanshan Zhao, Conference Organizing Committee Chair*

## Upcoming LiDS Webinars

- Title: Mediation Analysis with Failure Time Outcomes
- Presenter: Linda Valeri, Columbia University, NY, USA
- Date and Time: Friday, March 3, 2023, 10:00 a.m.–12:00 p.m. ET (This course will be taught via Zoom)
- Sponsor: Lifetime Data Science Section



**Registration Deadline** Friday, March 3, 2023, at 9:30 a.m. Eastern time

**Course Description** The course covers recent developments in causal mediation analysis for failure time outcomes and provide practical tools to implement these techniques. Mediation analysis concerns assessing the mechanisms and pathways by which causal effects operate. The course covers the relationship between traditional methods for mediation in epidemiology and the social sciences and new methods in causal inference. For time-to-event outcomes, we discuss when the standard approaches to mediation analysis are valid. Using ideas from causal inference

and natural direct and indirect effects, alternative mediation analysis techniques are described when the standard approaches do not work. The no-confounding assumptions needed for these techniques are described. SAS, R and Stata macros to implement these techniques are covered. The methods will be illustrated by an application.

### Part 1: Background and Review of Methodology

- An introduction to mediation analysis under the counterfactual framework
- Natural direct and indirect effects in a survival analysis context
- Regression approaches for direct and indirect effects in the presence of failure time outcomes
- Inference and software for mediation analysis

### Part 2: Application and Extensions

- Application: Evaluating interventions to reduce racial disparities in cancer survival
- Extensions: Mediation analysis in the presence of semi-competing risks

*Esra Kurum*, Webinar Committee Chair

## New Articles from Lifetime Data Analysis



Lifetime Data Analysis is the only journal dedicated to statistical methods and applications for lifetime data. The journal advances and promotes statistical science in various applied fields that deal with lifetime data, including actuarial science, economics, engineering, environmental sciences, management, medicine, operations research, public health, and social and behavioral sciences. The journal can

be accessed at <https://link.springer.com/journal/10985>.

The January 2023 issue (Volume 29, number 1) of Lifetime Data Analysis has been published:

- Joint modeling of generalized scale-change models for recurrent event and failure time data *by* X. Wang, & L. Sun. Pages 1–33
- Flexible two-piece distributions for right censored survival data *by* W.B. Ewnetu, I. Gijbels, & A. Verhasselt. Pages 34–65
- A general class of promotion time cure rate models with a new biological interpretation *by* Y.M. Gómez, D.I. Gallardo, M. Bourguignon, E. Bertolli, & V.F. Calsavara. Pages 66–86
- Semiparametric regression analysis of doubly-censored data with applications to incubation period estimation *by* K.Y. Wong, Q. Zhou, & T. Hu. Pages 87–114
- Double bias correction for high-dimensional sparse additive hazards regression with covariate measurement errors *by* X. Wang, J. Huang, G. Yin, J. Huang, & Y. Wu. Pages 115–141
- A uniformisation-driven algorithm for inference-related estimation of a phase-type ageing model *by* B. Cheng, & R. Mamon. Pages 142–187
- A flexible parametric approach for analyzing arbitrarily censored data that are potentially subject to left truncation under the proportional hazards model *by* P.W.W. Gamage, C.S. McMahan, & L. Wang. Pages 188–212

- Bayesian Design of Clinical Trials Using Joint Cure Rate Models for Longitudinal and Time-to-Event Data *by* J. Xu, M.A. Psioda, & J.G. Ibrahim. Pages 213–233
- A series of two-sample non-parametric tests for quantile residual life time *by* Y. Liu, L. Wu, G. Tang, & A.S. Wahed. Pages 234–252

Articles in the October 2022 issue (Volume 28, number 4) are:

- Special issue dedicated to David Oakes *by* J.H. Jeong, & A.K. Manatunga. Pages 543–545
- On the targets of inference with multivariate failure time data *by* R.L. Prentice Pages 546–559
- Marker-dependent observation and carry-forward of internal covariates in Cox regression *by* R.J. Cook, J.F. Lawless, & B. Xie. Pages 560–584
- Inference for transition probabilities in non-Markov multi-state models *by* P.K. Andersen, E.N.S. Wandall, & M.P. Perme. Pages 585–604
- Screening for chronic diseases: optimizing lead time through balancing prescribed frequency and individual adherence *by* J.D. Rice, B.A. Johnson, & R.L. Strawderman. Pages 605–636
- Accounting for delayed entry into observational studies and clinical trials: length-biased sampling and restricted mean survival time *by* M.-L.-T. Lee, J. Lawrence, Y. Chen, & G.A. Whitmore. Pages 637–658
- Bias correction via outcome reassignment for cross-sectional data with binary disease outcome *by* M.-C. Wang, & Y. Zhu. Pages 659–674
- Assessing dynamic covariate effects with survival data *by* Y. Cui, & L. Peng. Pages 675–699
- Choice of time scale for analysis of recurrent events data *by* P. Hougaard Pages 700–722
- Median regression models for clustered, interval-censored survival data - An application to prostate surgery study *by* D. Sinha, P. Basak, & S.R. Lipsitz. Pages 723–743
- Semiparametric single-index models for optimal treatment regimens with censored outcomes *by* J. Wang, D. Zeng, & D.Y. Lin. Pages 744–763

*Mei-Ling Ting Lee*, Editor-in-Chief, Lifetime Data Analysis

## Win Ratio Regression Using the {WR} Package

The win ratio analysis of hierarchical composite endpoints (e.g., death > hospitalization) has come a long way since it was first proposed by Pocock et al. (2012) in the *European Heart Journal*. One remarkable development, for example, is the extension from two-sample comparison to regression, and that is fully implemented in the R-package WR (<https://cran.r-project.org/package=WR>).

### Proportional win-fractions (PW) model

As in the regression analysis of single events, a model is needed to ensure that all parameters have meaningful interpretations. Let  $D$  and  $T$  denote the survival time and time to the first nonfatal event (e.g., hospitalization), respectively, and let  $\mathbf{Z}$  be a  $p$ -vector of covariates. Then, the composite outcomes consist of  $\mathbf{Y} = (D, T)$ , with  $D$  prioritized over  $T$ . To model the win ratio for  $\mathbf{Y}$  against  $\mathbf{Z}$ , consider two independent patients indexed by

$i$  and  $j$ , both followed up to time  $t > 0$ . Define an indicator of patient  $i$  “winning” (i.e., having a better outcome) against patient  $j$  by comparing their survival and nonfatal event times sequentially in that time window. Per Pocock et al. (2012)’s original proposal, this is expressed as

$$W(\mathbf{Y}_i, \mathbf{Y}_j)(t) = I(D_j < D_i \wedge t) + I(D_i \wedge D_j > t, T_j < T_i \wedge t),$$

where  $a \wedge b = \min(a, b)$ , though other rules involving recurrent events could be easily substituted (Mao, Kim, and Li, 2022).

With  $\mathbf{Y}_i$  and  $\mathbf{Y}_j$  viewed as random draws from their respective covariate groups, the covariate-specific population win ratio is  $WR(t; \mathbf{Z}_i, \mathbf{Z}_j) := E\{W(\mathbf{Y}_i, \mathbf{Y}_j)(t) \mid \mathbf{Z}_i, \mathbf{Z}_j\} / E\{W(\mathbf{Y}_j, \mathbf{Y}_i)(t) \mid \mathbf{Z}_i, \mathbf{Z}_j\}$ , where the numerator and denominator are the fractions of wins and losses comparing the two sub-populations. A **proportional win-fractions (PW)** model (Mao and Wang, 2021) specifies

$$WR(t; \mathbf{Z}_i, \mathbf{Z}_j) = \exp\{\boldsymbol{\beta}^T(\mathbf{Z}_i - \mathbf{Z}_j)\}. \quad (1)$$

That is, we assume that the win (and loss) fractions are proportional over time, resulting in a constant win ratio upon which the covariates act multiplicatively. Indeed, under model (1), the components of  $\boldsymbol{\beta}$  can be interpreted as the log-win ratios associated with unit increases in the corresponding covariates. For example, if  $Z$  is a treatment indicator, then  $\exp(\beta)$  is just the win ratio comparing the treatment to control. In general, we can obtain consistent estimates of  $\boldsymbol{\beta}$  based on censored data regardless of the censoring distribution, so long as censoring is independent of the outcomes given the covariates (Mao and Wang, 2021).

The proportionality of each covariate can be checked by plotting the cumulative residuals between the observed and model-based win counts over time. This shares a similar idea to Lin et al. (1993)’s approach to checking the proportional hazards assumption in the Cox model. If a categorical covariate, e.g., sex, is found to violate proportionality, we can *stratify* the model on it by restricting the  $(i, j)$  pairs under comparison in (1) within each stratum (Wang and Mao, 2022), e.g., males to males and females to females.

## Basic functionalities

To use the WR package to fit PW models, organize your data in the “long format”, with an `ID` vector holding unique patient identifiers. Additionally, we need a `time` vector containing the event times and a `status` vector indicating the corresponding event type, with 1=death; 2=non-fatal event; 0=censoring. Finally, we need a covariate matrix `Z` with a commensurate number of rows. Each column of `Z` represents a covariate. All covariates must be time-constant within the patient. A categorical `strata` variable is optional if a stratified model is desired.

The main function to fit the model is

```
obj <- pwreg(ID, time, status, Z, strata=NULL)
```

The returned object `obj` is of class `pwreg`, which contains a `beta` vector for  $\hat{\boldsymbol{\beta}}$  and a `Var` matrix for  $\text{var}(\hat{\boldsymbol{\beta}})$ . For model diagnostics, use `sp <- score.proc(obj)` to compute the residual-based score processes and `plot(sp, k)` to display them, where `k` specifies the  $k$ th covariate to plot ( $k = 1, \dots, p$ ). For detailed usage, refer to the package documentation.

## A real example

To illustrate, consider a dataset from the HF-ACTION study consisting of 451 non-ischemic heart failure patients. The study was conducted between April 2003 through Feb 2007 at 82 sites in the USA, Canada, and France (O’Connor et al., 2009). It aimed to evaluate the effect of adding aerobic exercise training to usual care on patient outcomes. The primary endpoint was a composite of all-cause death and all-cause hospitalization.

We first load the WR package, which contains the analysis dataset `non_ischemic`.

```
library(WR)
```

The dataset with a select number of variables (re-labeled) looks like the following:

```
non_ischemic[1:4,]
#   ID time status Training vs Usual Age (year)
# 1 1 221 2 0 62
# 2 1 383 0 0 62
# 3 2 23 2 0 75
# 4 2 1400 0 0 75
#   Male vs Female Black vs White Other vs White BMI LVEF
# 1 1 0 0 0 25.2 32.2
# 2 1 0 0 0 25.2 32.2
# 3 1 1 1 0 23.0 21.7
# 4 1 1 1 0 23.0 21.7
#   Hypertension COPD
# 1 0 0
# 2 0 0
# 3 1 0
# 4 1 0
```

Now, use `pwreg()` to fit a PW model against the covariates shown above:

```
# get the number of rows and number of covariates
nr <- nrow(non_ischemic)
p <- ncol(non_ischemic)-3

# extract ID, time, status and covariates matrix Z
# from the data.
# note that: ID, time and status should be column vector.
# covariatesZ should be (nr, p) matrix.
ID <- non_ischemic[,"ID"]
time <- non_ischemic[,"time"]/365.25 # days to years
status <- non_ischemic[,"status"]
Z <- as.matrix(non_ischemic[,4:(3+p)],nr,p)

# pass the data to the function
pwreg.obj <- pwreg(ID=ID,time=time,status=status,Z=Z)
print(pwreg.obj)
```

Included in the output is a table for the fitted log-win ratios ( $\hat{\boldsymbol{\beta}}$ ) and their standard errors, along with the corresponding  $p$ -values:

```
# Estimates for Regression parameters:
#           Estimate      se z.value p.value
# Training vs Usual  0.19959  0.12471  1.60  0.110
# Age (year)        -0.01081  0.00538 -2.01  0.045 *
# Male vs Female    -0.15133  0.12865 -1.18  0.239
# Black vs White    -0.30074  0.14488 -2.08  0.038 *
# Other vs White    -0.32767  0.32914 -1.00  0.319
# BMI               -0.01642  0.00906 -1.81  0.070 .
# LVEF              0.02027  0.00858  2.36  0.018 *
# Hypertension      -0.04905  0.14133 -0.35  0.729
```

```
# COPD          -0.35046  0.19847  -1.77  0.077 .
# ---
# Signif. codes:
# 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Another table transforms the estimates onto the win-ratio scale, i.e.,  $\exp(\hat{\beta})$ , and shows their 95% confidence intervals:

```
# Point and interval estimates for the win ratios:
#
#           Win Ratio 95% lower CL 95% higher CL
# Training vs Usual    1.221      0.956      1.559
# Age (year)          0.989      0.979      1.000
# Male vs Female      0.860      0.668      1.106
# Black vs White      0.740      0.557      0.983
# Other vs White      0.721      0.378      1.374
# BMI                 0.984      0.966      1.001
# LVEF                1.020      1.003      1.038
# Hypertension        0.952      0.722      1.256
# COPD                0.704      0.477      1.039
```

We can see that a patient in exercise training is  $1.221 - 1 = 22.1\%$  more likely to have better (survival-prioritized) composite outcomes than one in usual care. However, the difference is statistically insignificant. In addition, younger age, white race, higher LVEF are significantly associated with more favorable outcomes, while the beneficial effects of low BMI and absence of COPD history are borderline significant.

To assess the effect of race (white, black, or other), we test the null hypothesis

$$H_0: \beta_4 = \beta_5 = 0.$$

We conduct a 2-df Chi-square Wald test based on  $(\hat{\beta}_4, \hat{\beta}_5)^T$ :

```
#extract estimates of (\beta_4, \beta_5)
beta <- matrix(pwreg.obj$beta[4:5])
#extract estimated covariance matrix for (\beta_4, \beta_5)
Sigma <- pwreg.obj$Var[4:5,4:5]
#compute chisq statistic in quadratic form
chistats <- t(beta) %*% solve(Sigma) %*% beta

# compare the Wald statistic with the reference
# distribution of chisq(2) to obtain the p-value
1 - pchisq(chistats, df=2)
#           [,1]
# [1,] 0.103
```

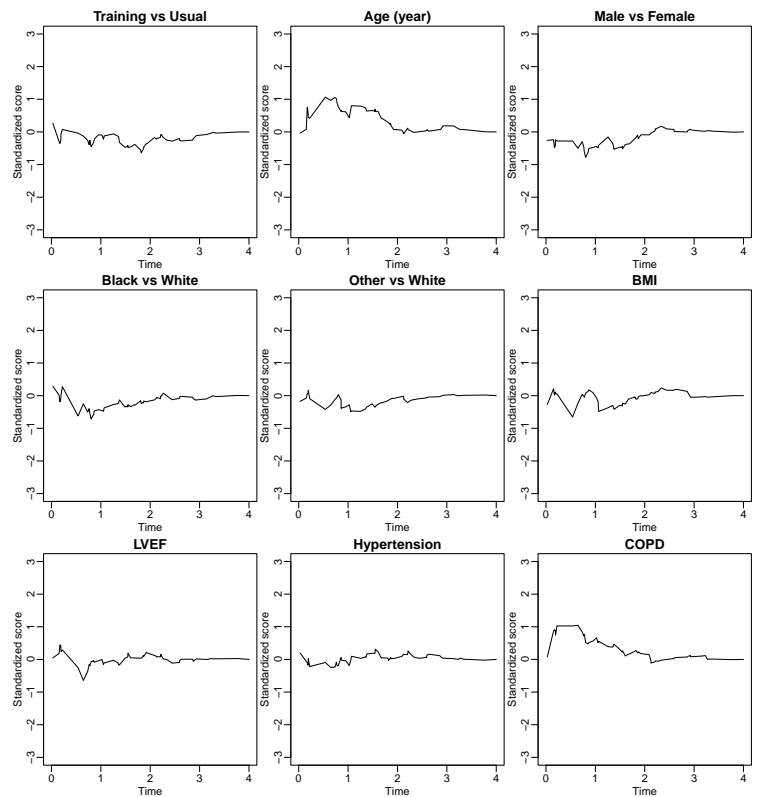
The  $p$ -value is 0.103. So the overall effect of race is non-significant.

Finally, use `score.proc()` to compute and plot the score process for each covariate:

```
# compute the score processes
score.obj <- score.proc(pwreg.obj)
# plot the 9 score processes in a 3 by 3
# multi-panel figure
par(mfrow = c(3,3))
for(i in c(1:9)){
  plot(score.obj, k = i)
}
```

Because the processes are standardized to have unit variance, they are most likely bounded in  $[-2, 2]$ , centered around zero with no clear trend if proportionality holds. That is mostly the case for the plots above. We thus conclude that the model assumption is satisfied by all covariates.

On the other hand, if we identified a non-proportional covariate, say COPD, we could address that by fitting a stratified model:



```
COPD <- Z[,9] # extract the COPD variable
Z <- Z[,1:8] # take it out of the covariate matrix
# fit a COPD-stratified model
obj <- pwreg(ID=ID,time=time,status=status,Z=Z,strata=COPD)
```

It is left to the reader to explore the results and compare them with the unstratified model.

## References

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Lu Mao  
Associate Professor  
Department of Biostatistics and Medical  
Informatics  
School of Medicine and Public Health  
University of Wisconsin — Madison  
Email: lmao@biostat.wisc.edu