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Rejoinder: Time-Dynamic Profiling with Application to Hospital Readmission Among Patients on Dialysis

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We thank the Editors for the opportunity to publish our article with discussion and we are grateful to the discussants. The diverse perspectives provided by the discussants are indeed valuable and contain many potential directions for further research. We hope that our work presented will generate further innovations in modeling time-varying effects in the context of profiling models.

Insightful comments were provided by professors Kalbfleisch and He (hereafter referred to as KH). Indeed, our proposed fixed effects (FE) model for time dependent assessment of dialysis facilities was inspired by the works of KH and colleagues (He et al. 2013, Kalbfleisch and Wolfe 2013) and also based on our own simulation studies which supported many of the advantages of FE models over random effects (RE) models reported by KH (Chen et al. 2017), especially in the dialysis population where patients are admitted to the hospital twice each year on average and where baseline 30-day (unplanned) readmission is not rare (about 30%, USRDS 2012). Professor Normand and colleagues (hereafter referred to as HZN) have been in the forefront of the development of methods for assessing the quality of health care providers for over 20 years and have contributed to the methodology adopted by the Centers for Medicare and Medicaid Services (CMS). We appreciate the background provided by HZN and the discussion of the policy-related aspects. Finally, we thank professor Goetghebeur for a stimulating discussion of our paper from a causal inference perspective. As many of the points brought up by the discussants were related, we try to touch upon the main points below grouped by related themes.

1 Mortality as a Competing Risk

The discussants raised good points regarding the interpretations of the proposed time-varying metric, $SDRR(t)$, without information on mortality. Mortality is indeed a complicating issue. We note that the literature on standard (annual) profiling assesses readmission and mortality in separate models. Similarly, we developed $SDRR(t)$ for assessing the readmission rate in a partly conditional model, conditional on being alive, which we believe is a useful first step. However, interpretations on overall facility

performance would be most meaningful if combined with facility profiling results based on mortality. As mentioned in the Discussion section of our article, an alternative approach is to jointly model mortality/survival and hospital readmissions, which we are currently investigating.

A related point was raised by professor Goetghebeur on the exclusion of hospitalizations which end in death, inherent also in standard profiling through SRR. The reason for excluding index hospitalizations that result in death within 30 days is because there would be no chance for a readmission, and also 30-day mortality is treated as a separate outcome. This relates again to our discussion above on the traditional practice of developing separate profiling models based on mortality and other adverse patient outcomes.

2 Comparison of Facility Performance

The discussants brought up issues on comparison of facility performance, within the context of direct and indirect standardization. The discussants also pointed out that regression models may be overreaching or extrapolating when facility effects are applied outside of the case-mix of a particular facility with direct standardization. We agree with this view and focused exclusively on $SDRR(t)$ with indirect standardization in our paper which provides a measure for each facility relative to a reference (e.g., national norm) for patients actually treated at the given facility. We also note that it may be an overreach for the proposed model when facility effects are applied to other facilities with a different mortality profile. Hence, we believe the direct standardization version of $SDRR(t)$ suggested by KH would be meaningful for comparisons between facilities not only with similar case-mix but also with similar mortality profiles.

3 Issues Related to the Outcome Considered

A fair amount of the discussion was on issues related to the modeled outcome of hospital readmissions and comparisons and contrasts with modeling similar outcomes such as general hospitalizations. We would like to start by noting that the proposed methodology would apply readily also to modeling general hospitalizations. As correctly pointed out by KH, the outcome/modeling considered of hospital readmission conditions on the existence of an index hospitalization. Hence we agree with professor Goetghebeur that facility effect estimates would be more influenced by patients with higher rates of hospitalizations in general since they contribute more data points (index hospitalizations) for estimation. We view this as a consequence of the definition of the outcome considered. Note that this consideration does not apply to modeling general hospitalization counts, where the outcome is no longer conditional, but either refers to the actual count of hospitalization discharges or a binary indicator of the existence of hospitalization discharges in discrete time intervals. We appreciate KH for pointing out the work of Liu and colleagues (2012), on modeling the sequence of hospitalizations by a counting process $N_{ij}(t)$. Our partly conditional model, conditional on being alive, is similar to the approach in Liu et al. (2012), which is a partial marginal model.

4 Adjustment for Covariates at Initiation of Dialysis

Also related to the particular outcome considered – hospital readmissions – the discussants touched upon an important limitation in the proposed modeling. In order not to adjust for time-varying covariates that may explain away facility effects, the model only adjusts for covariates prior to dialysis. This is not the case for the standard formulation of SRR, where each index hospitalization is treated as a separate case and hence the modeling can adjust for case-mix at the time of the index hospitalization. As HZN points out, adjustment for case-mix from initiation of dialysis would work better for index hospitalizations close to initiation of dialysis, but residual confounding can build for index hospitalizations far away from initiation of dialysis. This point can be considered in determining the total follow-up time after initiation of dialysis for TDP. However, this consideration needs to be balanced by the fact that too short of a follow-up may lead to unstable results in smoothing based estimation procedures. Note again that, as pointed out by KH, adjustments for case-mix from initiation of dialysis may be more plausible for the outcome of general hospitalizations.

5 Choice of Time Scale and Connections to Policy

KH discussed the choice of calendar time as an alternative time scale (instead of time from initiation of dialysis). This choice depends on the main objective of the profiling analysis (discussed more below). We agree with KH that when the main interest is in detecting quality problems by regulatory agencies and tied to annual payment, the choice of a chronological time scale and a prevalent cohort are natural. Our proposed model would indeed be applicable to this alternative time scale. As noted by KH, “one could also entertain models which allow both time scales by adjusting for specific parametric functions of chronological time in the model (M1).” We alluded to this in the Discussion section of our article and we have recently developed a more general varying-coefficient model (for multilevel risk factors) that can accommodate both time scales by adjusting for a nonparametric function of chronological time (Li et al. 2017).

With respect to the more general policy discussions provided by HZN, we first note that the results of profiling modeling are utilized for multiple objectives, including: (1) identifying providers with below standard performance by government agencies (e.g., CMS) for regulatory or payment purposes, (2) conveying information to patients regarding the quality of care, and (3) informing potential areas for improvement with respect to patient treatment strategies and processes of care among others. Policy questions typically fall under category (1) and desired characteristics of a quality measure that appeal to stakeholders are even more complicated for patients with end-stage renal disease (ESRD) because of the complexity of care for dialysis patients and the critical need for coordination of care between hospital and dialysis facility care teams. In the discussion, HZN stated: “we find it difficult to attribute responsibility of post-discharge care following a hospitalization to the dialysis center rather than to the hospital where the hospitalization took place ... “. Although this concern is understandable, there are competing policy objectives that are unique to dialysis patients. To put this into context, a large proportion of dialysis patient readmissions occur within the first week after index discharge (CMS 2014), but there is no standard of discharge coordination between hospitals and dialysis facilities. Indeed, the dialysis facility patient-care staff may

not see patients post discharge until the next dialysis session which could be several days later. Therefore, close coordination of care between hospitals and dialysis facilities is needed. Also, key clinical parameters (e.g., anemia, serum albumin, and mineral metabolism and bone disease) as well as dry weights may have substantially changed over the course of hospitalization, and in prior studies of dialysis patients clinical parameters were found to be significantly changed after hospitalization (Chan et al. 2009). Therefore, care coordination and discharge planning are paramount to early identification and intervention for recurrent illness immediately following discharge. The policy rationale for assessing 30-day hospital readmission among dialysis facilities is to affect care processes, and, specifically to encourage close coordination of care between discharging hospitals and dialysis facilities (CMS 2014), which currently there is no standard. See also Wish (2014) and discussion by KH, Section 2.

Although we avoided discussion of policy-related issues in our paper, we truly appreciate HZN for highlighting this important motivation to the discussion of our paper. We take this opportunity to also highlight objective (3) above. As pointed out in our paper, methods to monitor patient outcomes continuously over time are of particular relevance for patients on dialysis, since they require continuous medical care on maintenance dialysis and are at high risk for hospitalization. Being able to estimate the readmission (or hospitalization) risk trajectory for each facility over time from the start of dialysis, relative to a reference, is useful to flag facilities (as well as time periods) for further examination of care processes/factors for improvement, independent of regulatory or payment reimbursement issues. Finally, implemented policies that involve health care reimbursement based on (feasible and simple) quality measures can result in anticipated outcomes as well as driving unanticipated consequences. For example, do short-term (annual) measures discourage exploration of innovations to achieve better patient outcomes over a longer period of time? Despite the limitations of our proposed method, we hope that it generates research that goes beyond annual (time-static) measures.

6 Causal Inference and Between Facility Variation

As noted in the above sections, the exclusion of hospitalizations where death occurs within 30 days of index hospitalization and inclusion of hospital random effects to arrive at shrinkage (biased) estimates are both inherent in standard (annual) profiling, issues that Goetghebeur discussed in our time-varying setting. Furthermore, annual profiling models are typically based on administrative databases in practice that do not have many relevant patient-level factors (e.g., genetics) or facility-level factors unrelated to care that should be accounted for. Indeed, these issues, among others, pose problems when they are viewed through the lens of causal inference and they are further complicated in the time-varying effect setting as discussed by professor Goetghebeur. As KH pointed out succinctly, “Although widely used, the term facility effect is a poor one since it carries a connotation of causality that may not be true”. We also pointed out in the Discussion section of our paper, that efforts to further model additional relevant factors (patient and facility factors not related to care) to reduce total unexplained between-facility variation are important. KH suggested another interesting approach that seems to flexibly allow for one to specify a proportion of total between-facility variation as being attributable to the quality of care

(Kalbfleisch et al. 2017). Efforts to account for variation that are due to factors beyond the facility's control (but still achieve the policy objectives, e.g. encouraging close coordination of care between dialysis facilities and discharging hospitals) will improve interpretation of 'facility effect' measures and also contribute towards acceptance by stakeholders. We are thankful for the insightful discussion of KH on between-facility variation and the use of the empirical null. In particular, we look forward to the forthcoming work by professor Kalbfleisch et al. (2017) that specify a proportion of between-facility variation as due to quality of care.

7 Interaction Between Patient Factors and Health-Care Providers

Our work and others in 30-day hospital readmission have not considered interactions between patient factors and providers; the setting in which professor Goetghebeur and colleagues (Varewyck et al. 2016) examined these interactions focuses on the situation where some providers perform structurally better in certain subgroups of patients (e.g., some providers specializing in care for pediatrics vs. adult patients). Although this may be relevant in some contexts, we do not see this as pertinent in context of dialysis patient care.

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