**Variation and correlation of potential unintended consequences of antipsychotic reduction in Ontario nursing homes over time**

Daniel A. Harris, MPH, Laura C. Maclagan, MSc, Priscila Pequeno, MSc, Andrea Iaboni, MD, DPhil, Peter C. Austin, PhD, Laura C. Rosella, PhD, Jun Guan, MSc, Colleen J. Maxwell, PhD, Susan E. Bronskill, PhD

**TECHNICAL APPENDIX**

Similar to Gebregziabher et al.,1 we used multivariate generalized linear random effects models to jointly analyze facility-level time trends for potentially inappropriate antipsychotic use, antidepressant use, and relevant indications among nursing homes in Ontario, Canada between April 1, 2010 and December 31, 2019. Multivariate statistics represent a family of statistical methods that allow for the analysis of multiple outcome variables and their temporal evolutions,2-4 and have been applied to a range of research questions in health services research1, 5, 6 and clinical epidemiology7, 8.

The full multivariate model represents three separate random effects models, one for each outcome. The three models are linked together through their random effects. Random intercepts (i.e., facility-specific deviations in baseline medication use and relevant indications) and random slopes for time (i.e., facility-specific deviations in the time trends for medication use and relevant indications) were specified and linked together assuming a multivariate normal distribution with mean zero and covariance matrix *D*. The random intercept and random slope models for the three outcomes can be expressed as:1

$$E\left(Y\_{i,t}^{1}\right|b\_{i,1})=g^{-1}(β\_{0,1}+b\_{0,i,1}+\left(b\_{1,i,1}+β\_{1,1}\right)\*t\_{i})$$

$$E\left(Y\_{i,t}^{2}\right|b\_{i,2})=g^{-1}(β\_{0,2}+b\_{0,i,2}+\left(b\_{1,i,2}+β\_{1,2}\right)\*t\_{i})$$

$$E\left(Y\_{i,t}^{3}\right|b\_{i,3})=g^{-1}(β\_{0,3}+b\_{0,i,3}+\left(b\_{1,i,3}+β\_{1,3}\right)\*t\_{i})$$

$$b\_{i}=\left(\begin{matrix}\begin{matrix}b\_{i,1}\\b\_{i,2}\end{matrix}\\b\_{i,3}\end{matrix}\right)=\left(\begin{matrix}\begin{matrix}b\_{0,i,1}\\b\_{1, i,1}\end{matrix}\\\begin{matrix}\begin{matrix}b\_{0,i,2}\\\begin{matrix}b\_{1,i,2}\\b\_{0,i,3}\end{matrix}\end{matrix}\\b\_{1,i,3}\end{matrix}\end{matrix}\right)\~MVN(0,D\_{6x6})$$

Let $Y\_{i,t}^{k}$ represent each outcome *k* (k=1,2,3) for the *i*th facility (*i*=1…*N*) at the *t*th quarter (*t*=1…*T*). Random intercepts are denoted with $b\_{0,i,k}$. The fixed effect for time (quarter), modeled as a continuous covariate, is represented by $β\_{1,k}$, with a random slope for time represented by $b\_{1,i,k}$. The model link function is specified by *g-1*.1

All models were conducted using a binomial distribution and logit-link function. Both G-side (with Cholesky parameterization) and R-side (with variance components) random effects were specified. The number of model iterations was increased to 1,000 and Newton-Raphson ridge optimization with ridging was specified to aid model convergence. Last, facility-specific intercepts and time trends predicted from the model were saved and used to create descriptive plots and to compare nursing home characteristics by quintiles of their rates of change.

References

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