SENSITIVITY ANALYSIS OF THE CHANGE OF RENAL STONE OCCURRENCE RATES IN ASTRONAUTS USING URINE CHEMISTRIES

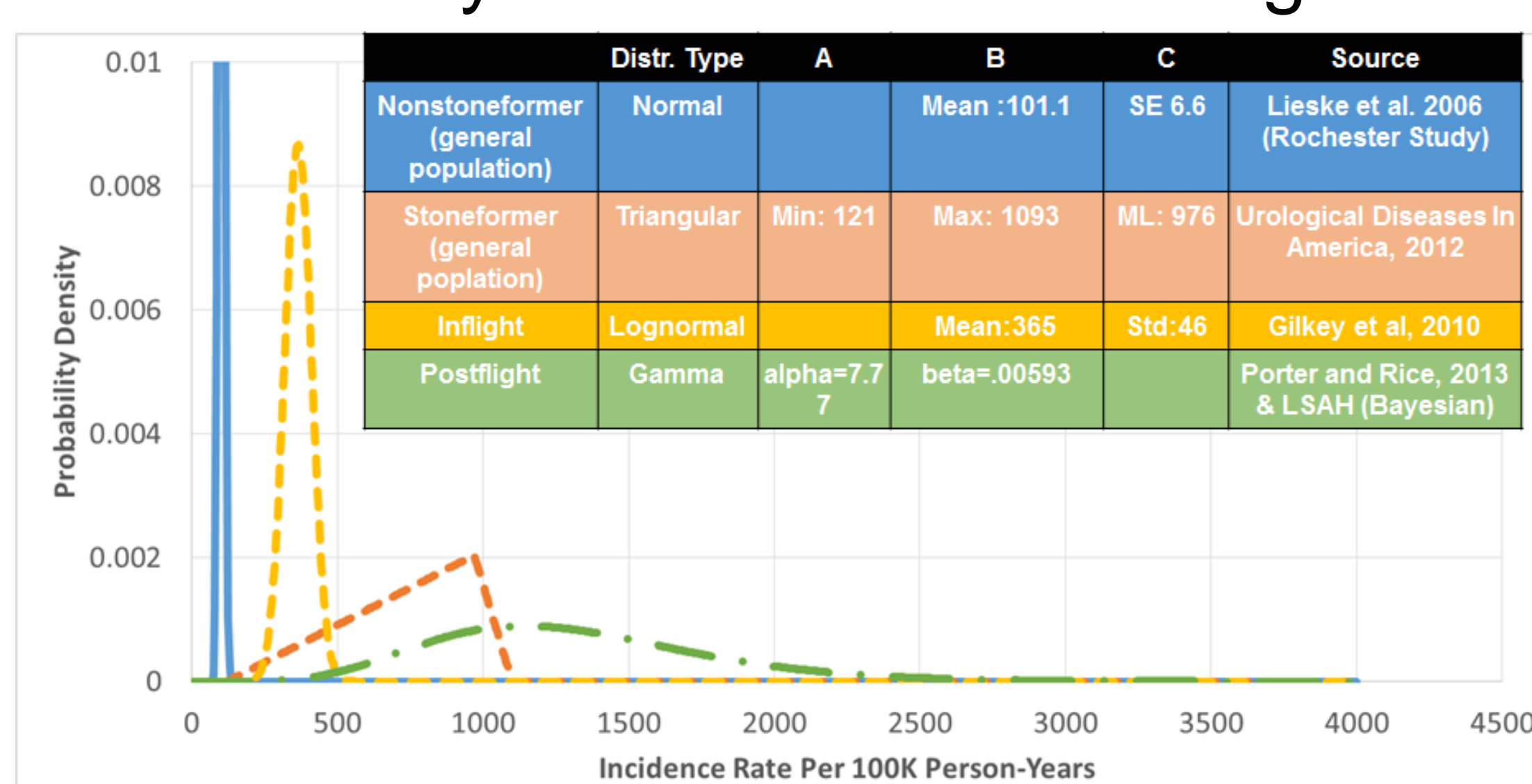J. Myers[1], D. Goodenow[1], S. Gokoglu[1], and M. Kassemi[2]

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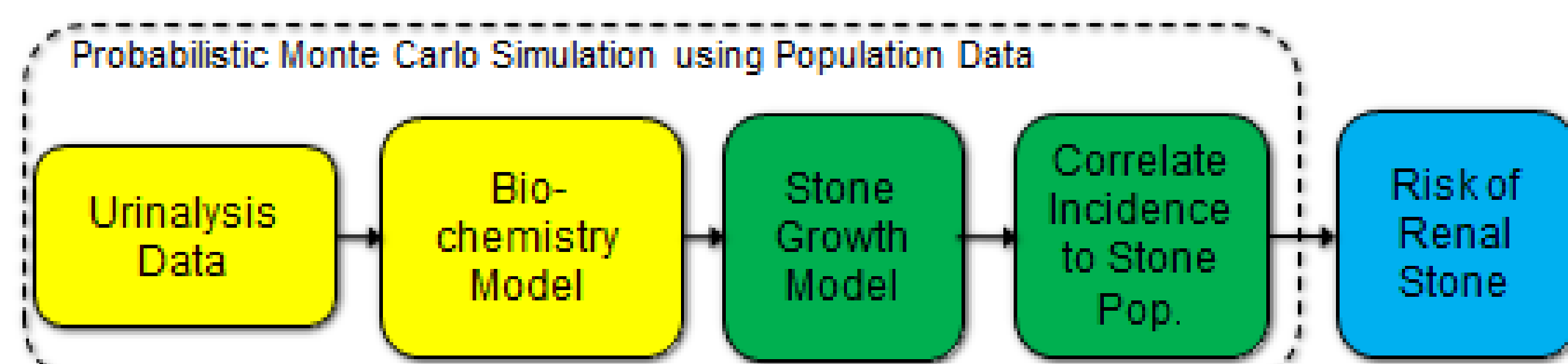
Introduction

Changes in urine chemistry, during and post-flight, potentially alter the likelihood of renal stones in astronauts. Although much is known about the effects of space flight on urine chemistry, no inflight incidences of renal stones in US astronauts exist and the question "How much does this risk change with space flight?" remains difficult to accurately quantify. Previous work by our group has illustrated the application of multi-factor deterministic and probabilistic modeling to assess the change in predicted likelihood of renal stone. Utilizing 1517 astronaut urine chemistries to inform the renal stone occurrence rate forecasting model, we performed a sensitivity analysis on urine chemistry components for their influence on predictions of renal stone size and rate of renal stone occurrence..

Background and Methods

- Astronauts exhibit a higher rate of renal stones within the first year of return from flight.
- The uncertainty in this estimate is large.

	Distr. Type	A	B	C	Source
Nonstoneformer (general population)	Normal		Mean :101.1	SE 6.6	Lieske et al. 2006 (Rochester Study)
Stoneformer (general poplation)	Triangular	Min: 121	Max: 1093	ML: 978	Urological Diseases in America, 2012
Inflight	Lognormal		Mean:365	Std:46	Gilkey et al 2010
Postflight	Gamma	alpha=7.77	beta=.00593		Porter and Rice, 2013 & LSAH (Bayesian)

We seek to improve this estimate using the Renal Stone prediction model:


Two stone growth models estimate the per person rate of stone formation for each flight phase after urine biochemistry speciation using the Joint Expert Speciation System (JESS) model :

- Max Stone – estimates of the maximum single stone size per 1 mL of urine from kinetics transport balance model.
- Saturation Index ($\sqrt{Supersaturation}$) of Calcium Oxalate, estimated from the JESS output.
- Poisson Regression correlation of each model output estimated 1-year renal stone occurrence rates utilizing 1517 astronaut urine chemistries from all phases of flight.

To assess the robustness of the model to address urine chemistry changes in all phases of flight, we applied a Partial Rank Correlation Coefficient (PRCC) analysis to estimates the sensitivity using partial correlation of the ranks of the generated input values to each generated output value.

- The technique is most appropriate for Monte Carlo systems with generally monotonic relations between input and output.

Results
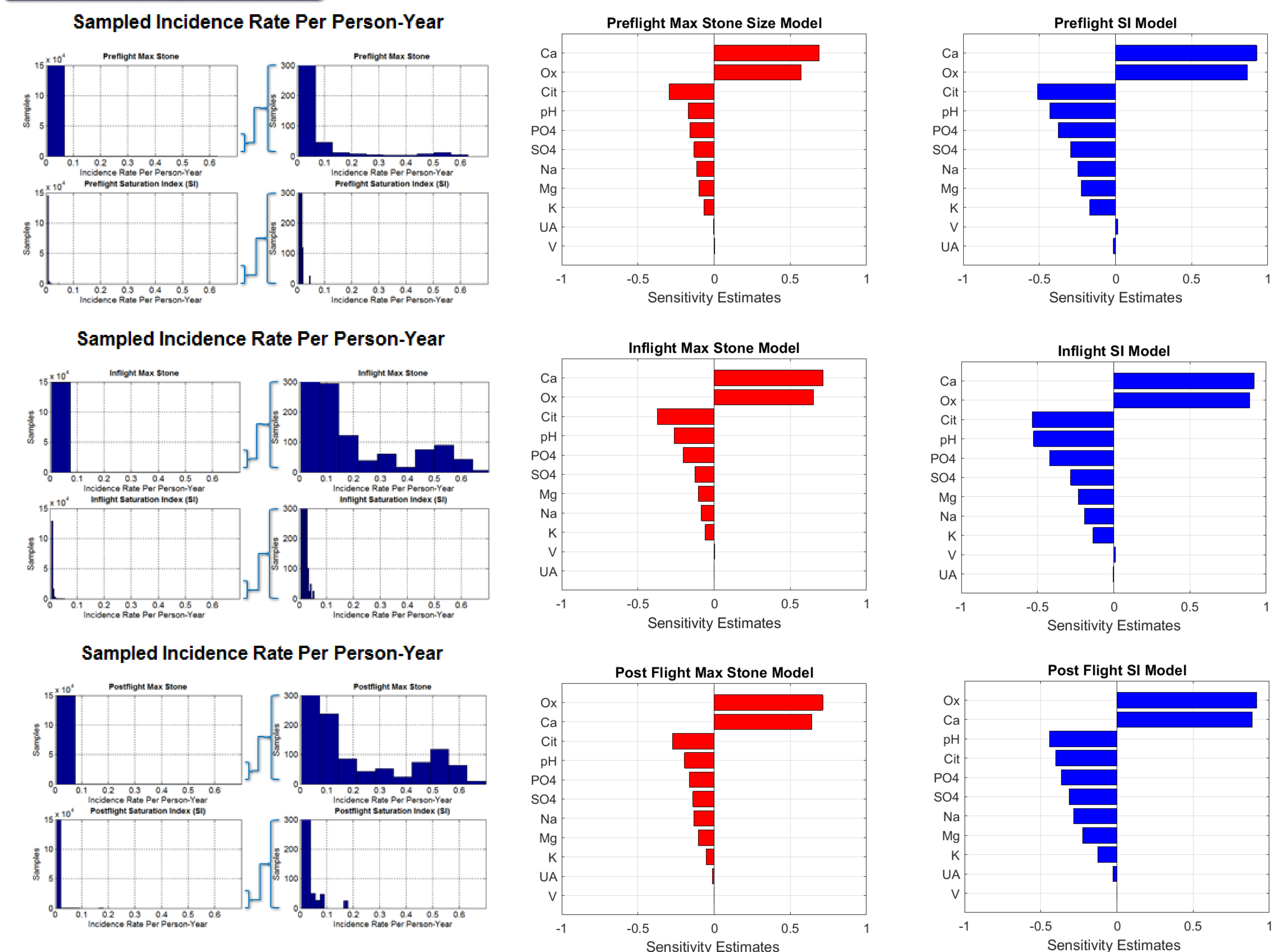
Legend

Ca	Ox	Cit	pH	PO4	SO4	Na	Mg	K	UA	V
Calcium (mol/L)	Oxalate (mol/L)	Citrate (mol/L)	pH	Phosphate (mol/L)	Sulfate (mol/L)	Sodium (mol/L)	Magnesium (mol/L)	Potassium (mol/L)	Uric Acid (mol/L)	Volume (L)

Note: The low sensitivity of urine volume is due to a normalization process. In the analysis, each urine chemistries was normalized by total urine volume. This normalization distributes the effects of urine volume to each component sensitivity and reduces the PRCC direct influence estimate.

Conclusions

- Ca and Ox: largest effect, increasing incidence rate,
- Cit and pH: largest effect, reducing the incidence rate.
- Flight Phase: small influence on how urine chemistry influences on the incidence rate.
- SI method is strongly influenced by Ca and Ox
- Max Stone approach is less influenced by uncertainty in urine chemistry parameters.

References

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