Estimating Hospital Acquired Infection Rates Using Prevalence Data

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TATFAR action 2.1 – Consultation and collaboration on a point-prevalence survey for healthcare-associated infections (HAIs)

ECDC, Stockholm, 15-16 May 2019

Expert Meeting on Prevalence to Incidence Conversion. Final Agenda

- Population - patients in a hospital.
- Design - cross-sectional sampling (prevalence).
- Main goal - estimating the burden of all types of health care-associated infections.
- **Our goal (secondary) - estimating the probability of acquiring an infection during hospitalization (incidence proportion/cumulative incidence).**
- Examples: CDC 2015: 199 hospitals in 10 states in the US (Magil et al. 2018); ECDC 2016-17: 1209 hospitals in 28 European countries (Suetens et al. 2018).

Conversion formula: prevalence → cumulative incidence

$$IP = PP \cdot \frac{LA}{LN - INT},$$

IP – Incidence prop. = proportion of patients acquired infection during hospitalization (among all patients hospitalized in a given period).

PP – Prevalence prop. = proportion of patients acquired infection before survey day (among all patients hospitalized on survey day).

LA – Average length of stay of all patients

LN-INT – Average length of infection (from infection to discharge)

These are empirical quantities, so the formula is not exact - it is when interpreted as probabilities and expectations.

- Berthelot, P., et al. (2007): estimated incidence proportion (from prevalence survey) is only about half as big as measured incidence proportion (from incidence cohort).
- Gastmeier, P., et al. (2001): confirm the formula, but don't recommend it (without giving much reasoning).
- Graves, N., et al. (2003): incidence proportions are generally lower than prevalences.
- Haore, H. G et al. (2005): large discrepancy between measured and calculated incidence - the estimated incidence was lower than the observed incidence.
- King, C., Aylin, P., & Holmes, A. (2014): find poor performance of Rhame & Sudderth and suggest replacing (LN - INT) with average duration of treatment.
- Meijs, A. P., et al. (2017): Rhame & Sudderth (1981) is far too unreliable, hence prevalence studies cannot replace incidence studies.

What was going wrong?
the Math
or
the Application?
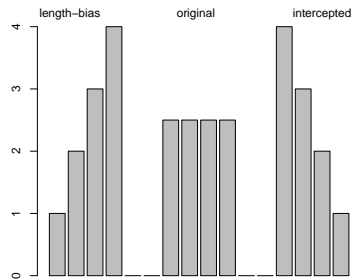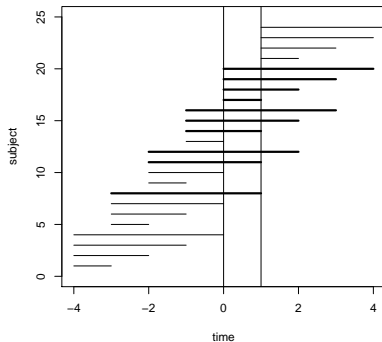
Conversion formula: Definitions and Assumptions

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- Population is in steady state.

$$IP = \frac{\text{Mean time from } \textbf{admission} \text{ to discharge, } \textbf{all} \text{ patients}}{\text{Mean time from } \textbf{first infection} \text{ to discharge, } \textbf{infected} \text{ patients}} \times PP$$

name	data	Theoretical justification?	comments
A	cohort	✓	rarely available
B	PPS + discharge	✓	inverse weighting
C	PPS + discharge	✗	simple average
D	PPS	✗	simple average
E	PPS	✓	Grenander
E1	PPS	✓	empirical

Results are based on 1000 replications.
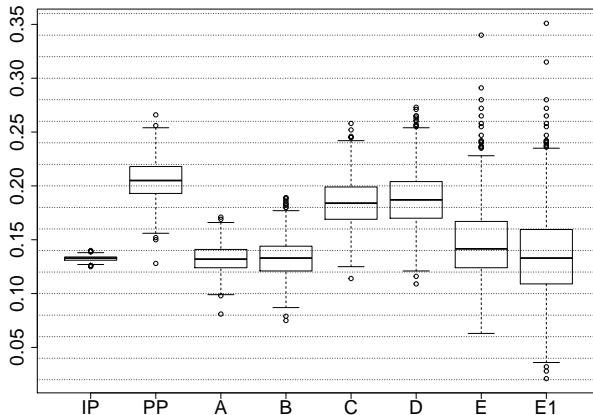
n	IP	PP	A	B	C	D	E	E1
498	0.133	0.206	0.133	0.133	0.185	0.188	0.147	0.136
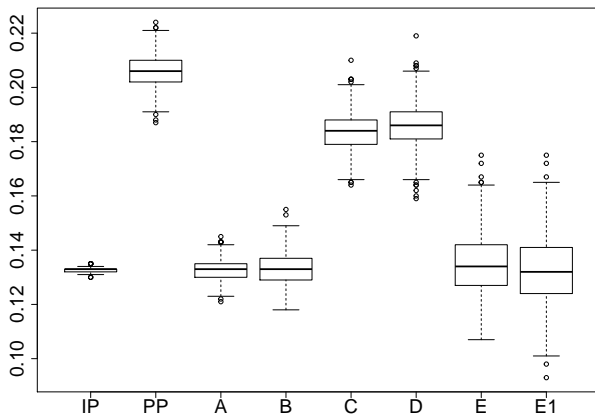
n	IP	PP	A	B	C	D	E	E1
4984	0.133	0.206	0.133	0.133	0.184	0.186	0.133	0.133
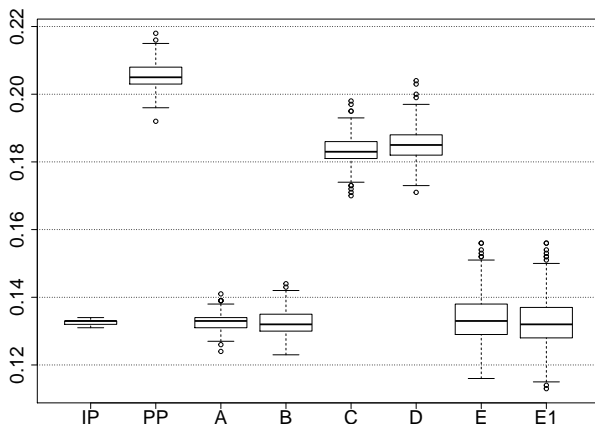
n	IP	PP	A	B	C	D	E	E1
14944	0.133	0.205	0.133	0.133	0.183	0.185	0.154	0.133
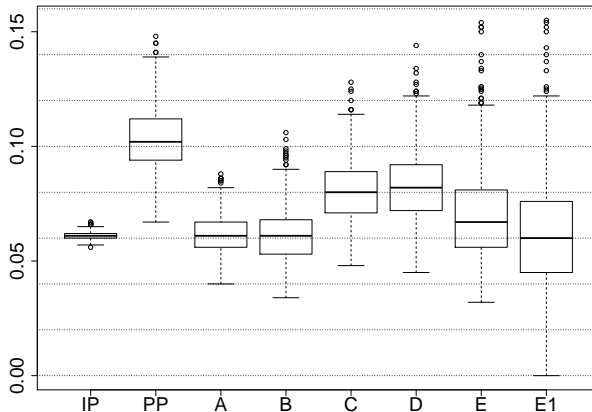
n	IP	PP	A	B	C	D	E	E1
507	0.061	0.103	0.061	0.061	0.080	0.082	0.070	0.062
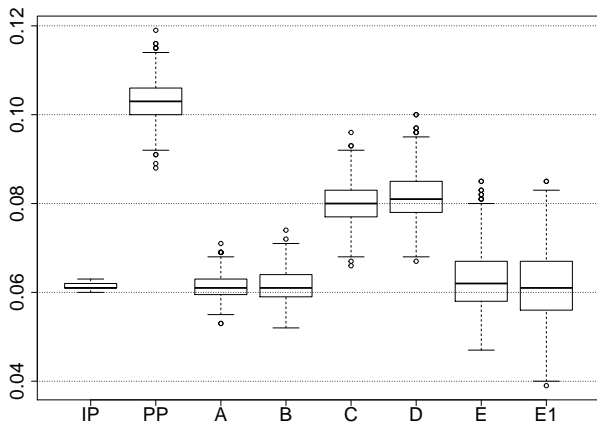
n	IP	PP	A	B	C	D	E	E1
5068	0.061	0.103	0.061	0.061	0.080	0.082	0.063	0.062
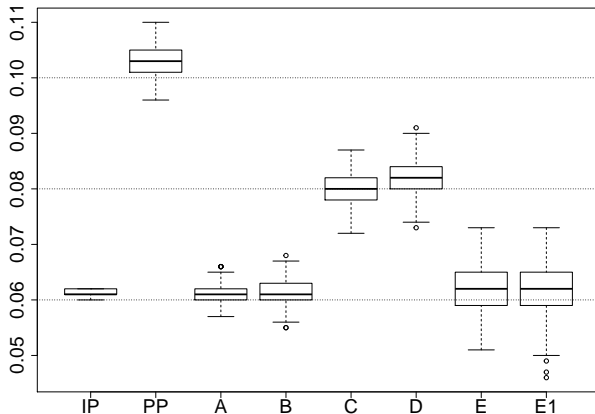
| n	IP	PP	A	B	C	D	E	E1
15200	0.061	0.103	0.061	0.061	0.080	0.082	0.062	0.062

Conclusions and Future Directions

- Ad-hoc methods are not recommended.
- Collect discharge data: efficient estimation; can test steady state; regression models.
- It is extremely important to collect reliable infection and admission data on the survey day.
- Definition of PP is important - use the correct inversion formula.
- New methods for different settings are on the way, but soon incidence data will be available???

References

- Magil et al. *New England Journal of Medicine*, 2018.

- Suetens et al. *Eurosurveillance*, 2018.

- Rhame and Sudderth. *American Journal of Epidemiology*, 1981.

- Berthelot et al. *Infection Control & Hospital Epidemiology*, 2007.

- Gastmeier et al. *Infection Control & Hospital Epidemiology*, 2001.

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- Meijs et al. *Epidemiology & Infection*, 2017.

- Mandel and Fluss. *Biometrika*, 2009.
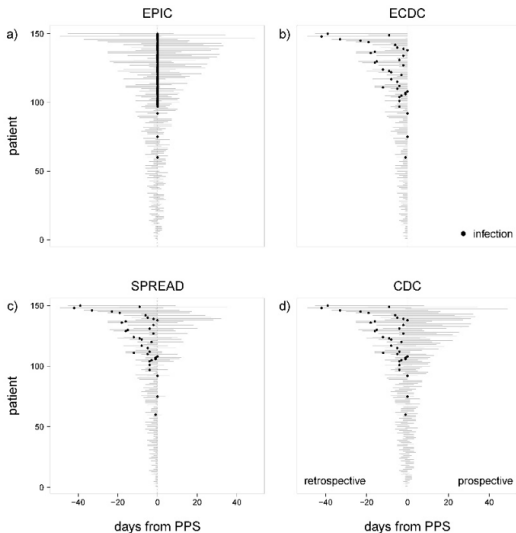
EPIC - Worldwide. ECDC - European Union. Spread - Brazil. CDC - USA.