Social contact and mixing patterns relevant to the spread of infectious diseases: a multi-country population-based survey

Workshop on Infectious Disease Epidemiology for Decision Making
12th December 2008, Brussels

Joël Mossong PhD
National Health Laboratory
Luxembourg
Background

• Major public health priorities
  – Preparing for outbreaks of directly transmitted pathogens
    • pandemic influenza, SARS
  – or controlling endemic diseases
    • TB, meningococcal diseases

• Mathematical models used to predicting impact of intervention
  – Vaccination, antivirals
  – Social distancing measures (school closures)
Background

• Models historically have assumed a priori contact structure without empirical basis
• Compared to Sexually Transmitted Diseases, little known about contact processes underlying spread of infections from person to person
Previous contact studies

• A small number of studies, but
  – small convenience samples
  – non-representative populations (university or school settings)

• Aim of our project:
  – large-scale, prospective, population-based survey of
    epidemiologically relevant social contact patterns.
  – in 8 European countries
  – common paper diary approach
  – covering all age groups including children
What is a relevant contact and how do we measure it?

• **Contact:**
  – at-risk event for transmitting infection by respiratory or droplet route

• **Physical proximity**
  – Difficult to record and measure objectively

• **Having a 1-to-1 conversation in the physical presence of or touching another person**
  – Fairly easy to remember and record in a diary
Diaries

• Participants asked to record on diary all persons contacted during 24 hour period
  – One line per person even if multiple contact events
• Day of the week randomly assigned
• Diary filled in prospectively, if possible
• Basic socio-demographic data of participant
• Parents to fill in diaries of young children on their behalf
  – Older children and teenagers (>9-10 years able to fill in themselves – result from pilot)
**EXAMPLE**

This is an example of how somebody might fill in one page of the diary.

<table>
<thead>
<tr>
<th>Age (or range)</th>
<th>Gender</th>
<th>Did you touch his/her skin?</th>
<th>How often do you have contact with this person in general?</th>
<th>Where did you have contact?</th>
<th>Total time spent with person during whole day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Y N</td>
<td>Daily or almost daily, About once or twice a week, About once or twice a month, Less than once a month, Never met before</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-9 (4-12)</td>
<td></td>
<td></td>
<td></td>
<td>Home, School / Work, Transport, Leisure, Other, College</td>
<td></td>
</tr>
<tr>
<td>10-14 (8-16)</td>
<td></td>
<td></td>
<td></td>
<td>Under 5 mins, 5-15 mins, 15 mins - 1 hr, 1 - 4 hrs, More than 4 hrs</td>
<td></td>
</tr>
</tbody>
</table>

The table above shows how to fill in the diary page with information about the age range, gender, skin contact, frequency of contact, and where the contact occurred, along with the total time spent with the person during the whole day.
Contact surveys conducted in 8 countries

- Pilot diary translated into local languages
- Belgium, Germany, Finland, Great Britain, Italy, Luxembourg, the Netherlands and Poland
- field work conducted by commercial survey/marketing research companies (except NL)
- Period: May 2005 - September 2006
- Participants broadly representative of population
  - In BE, IT, LU: random digit dialling on land lines
  - in DE, GB and PL: face-to-face method
  - in NL and FI via population registers
- Children/adolescents deliberately oversampled
  - Generally quota methodology for all age groups
Results, nr. of contacts

- 7290 diaries collected
  - mean 912, range 267 in NL-1328 in DE
- Total of 97904 contacts recorded (mean = 13.4)
  - Range: Germany (N=7.95) and Italy (N = 19.77)
- Consistent pattern of number of contacts by age
  - with a gradual rise with age in children
  - a peak among 10-19 year olds,
  - lower plateau in adults until the age of 50
  - decrease after 50
- Living in larger household size associated with more contacts
- Weekdays associated with 30-40% more contacts
- Overdispersion
  - negative binomial model
Table 1. Number of Recorded Contacts per Participant per Day by Different Characteristics and Relative Number of Contacts from the Weighted Multiple Censored Negative Binomial Regression Model

<table>
<thead>
<tr>
<th>Category</th>
<th>Covariate</th>
<th>Number of Participants</th>
<th>Mean (Standard Deviation) of Number of Reported Contacts</th>
<th>Relative Number of Reported Contacts (95% Confidence Interval)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of participant, y</td>
<td>0–4</td>
<td>660</td>
<td>10.21 (7.65)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>5–9</td>
<td>661</td>
<td>14.81 (10.09)</td>
<td>1.42 (1.28–1.55)</td>
</tr>
<tr>
<td></td>
<td>10–14</td>
<td>713</td>
<td>18.22 (12.27)</td>
<td>1.73 (1.57–1.90)</td>
</tr>
<tr>
<td></td>
<td>15–19</td>
<td>685</td>
<td>17.58 (12.03)</td>
<td>1.68 (1.52–1.84)</td>
</tr>
<tr>
<td></td>
<td>20–29</td>
<td>879</td>
<td>13.57 (10.60)</td>
<td>1.45 (1.33–1.57)</td>
</tr>
<tr>
<td></td>
<td>30–39</td>
<td>815</td>
<td>14.14 (10.15)</td>
<td>1.45 (1.34–1.57)</td>
</tr>
<tr>
<td></td>
<td>40–49</td>
<td>908</td>
<td>13.83 (10.66)</td>
<td>1.38 (1.27–1.50)</td>
</tr>
<tr>
<td></td>
<td>50–59</td>
<td>906</td>
<td>12.30 (10.23)</td>
<td>1.31 (1.20–1.42)</td>
</tr>
<tr>
<td></td>
<td>60–69</td>
<td>728</td>
<td>9.21 (7.96)</td>
<td>1.06 (0.96–1.16)</td>
</tr>
<tr>
<td></td>
<td>70+</td>
<td>270</td>
<td>6.89 (5.83)</td>
<td>0.81 (0.73–0.88)</td>
</tr>
<tr>
<td></td>
<td>Missing value</td>
<td>65</td>
<td>9.63 (9.05)</td>
<td>0.91 (0.86–1.17)</td>
</tr>
<tr>
<td>Sex of participant</td>
<td>Female</td>
<td>3,808</td>
<td>13.39 (10.57)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>3,429</td>
<td>13.51 (10.67)</td>
<td>0.99 (0.96–1.02)</td>
</tr>
<tr>
<td></td>
<td>Missing value</td>
<td>53</td>
<td>10.92 (8.60)</td>
<td>1.57 (1.09–2.05)</td>
</tr>
<tr>
<td>Household size</td>
<td>1</td>
<td>749</td>
<td>8.87 (8.27)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,645</td>
<td>10.65 (9.14)</td>
<td>1.17 (1.11–1.24)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1,683</td>
<td>12.87 (10.26)</td>
<td>1.20 (1.13–1.27)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2,041</td>
<td>15.84 (11.17)</td>
<td>1.36 (1.28–1.44)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>814</td>
<td>16.47 (11.21)</td>
<td>1.45 (1.35–1.56)</td>
</tr>
<tr>
<td></td>
<td>6+</td>
<td>358</td>
<td>17.69 (10.98)</td>
<td>1.55 (1.43–1.70)</td>
</tr>
<tr>
<td>Day of the week</td>
<td>Sunday</td>
<td>862</td>
<td>10.10 (8.76)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Monday</td>
<td>1,032</td>
<td>13.32 (10.31)</td>
<td>1.33 (1.24–1.41)</td>
</tr>
<tr>
<td></td>
<td>Tuesday</td>
<td>1,116</td>
<td>14.17 (10.63)</td>
<td>1.39 (1.31–1.48)</td>
</tr>
<tr>
<td></td>
<td>Wednesday</td>
<td>1,017</td>
<td>14.58 (11.14)</td>
<td>1.38 (1.29–1.47)</td>
</tr>
<tr>
<td></td>
<td>Thursday</td>
<td>1,069</td>
<td>14.70 (11.23)</td>
<td>1.41 (1.32–1.50)</td>
</tr>
<tr>
<td></td>
<td>Friday</td>
<td>1,122</td>
<td>14.72 (11.25)</td>
<td>1.43 (1.34–1.52)</td>
</tr>
<tr>
<td></td>
<td>Saturday</td>
<td>936</td>
<td>11.63 (9.11)</td>
<td>1.20 (1.12–1.28)</td>
</tr>
<tr>
<td></td>
<td>Missing value</td>
<td>136</td>
<td>12.48 (10.66)</td>
<td>1.24 (1.08–1.40)</td>
</tr>
<tr>
<td>Country**</td>
<td>BE</td>
<td>750</td>
<td>11.84 (9.85)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>DE</td>
<td>1,341</td>
<td>7.95 (6.26)</td>
<td>0.70 (0.65–0.74)</td>
</tr>
<tr>
<td></td>
<td>FI</td>
<td>1,006</td>
<td>11.06 (7.89)</td>
<td>0.94 (0.88–1.00)</td>
</tr>
<tr>
<td></td>
<td>GB</td>
<td>1,012</td>
<td>11.74 (7.67)</td>
<td>0.99 (0.92–1.05)</td>
</tr>
<tr>
<td></td>
<td>IT</td>
<td>849</td>
<td>19.77 (12.27)</td>
<td>1.66 (1.55–1.78)</td>
</tr>
<tr>
<td></td>
<td>LU</td>
<td>1,051</td>
<td>17.46 (12.61)</td>
<td>1.42 (1.33–1.51)</td>
</tr>
<tr>
<td></td>
<td>NL</td>
<td>269</td>
<td>13.85 (10.54)</td>
<td>1.34 (1.20–1.47)</td>
</tr>
<tr>
<td></td>
<td>PL</td>
<td>1,012</td>
<td>15.31 (11.45)</td>
<td>1.37 (1.28–1.47)</td>
</tr>
</tbody>
</table>
Physical contact = good proxy for intensity
Contact more intense at home, leisure or school

Diagram B:
- Comparison of non-physical and physical contacts across different settings (home, school, leisure, work, transport, otherplace, multiple).

Diagram D:
- Duration of contact frequency (daily, weekly, monthly, less often, first time) with categories for time intervals (4+ h, 1 - 4 h, 15 - 60 min, 5 - 15 min, < 5 min).
Locations of contact

- Leisure activities much more important than travel
Who mixes with whom
Impact on transmission dynamic modelling
Conclusions

• Age and intensity patterns of contact remarkably similar across different European countries
  – Although differences in reported number of contacts due to differences in methodology

• Contacts made by children and adolescents more assortative than contacts made by other age groups
  – Children and teenagers = an important driver for the initial spread of close-contact infections
Limitations

- At risk event defined as oral or physical communication event, not physical proximity
- Did not really assess full clustering of contacts
- Useful to validate with direct observational studies, particularly for young children where reporting by parental proxy is problematic
- Variations in diary design, recruitment and follow up, particularly professional contacts
Intensity & location

- Different measures of closeness of contact highly correlated
  - more intimate contacts are likely to carry a greater risk of transmission.

- Risk of infection in different settings varies
  - more intimate contacts at home or leisure settings,
  - least intimate contacts while travelling
  - highest incidence to be expected in school aged children

- Implications for contact tracing during outbreaks of a new infection.
  - >80% of all contacts occur at home, school, workplace or leisure settings
Future

• Compare and validate with other data sources
  – Other contact data or seroprevalence of infectious disease
• Full contact data available to interested researchers
• Diaries available in 9 different languages
• Focus on different high risk population groups
  – Hospitals, schools, children
Acknowledgments

• Study formed part of POLYMOD, a European Commission DG Research project funded within the Sixth Framework Programme, Contract number: SSP22-CT-2004-502084
Thanks

• J. Edmunds, M. Jit, A Melegaro, N. Gay: Health Protection Agency, UK
• N. Hens, M. Aerts, Z. Shkedy: Hasselt University, Belgium
• J. Wallinga, J. Heijne: RIVM, Netherlands
• P. Beutels, P. van Damme: University of Antwerp, Belgium
• K. Auranen: National Public Health Institute KTL, Finland
• R. Mikolajczyk, M. Kretzschmar: University of Bielefeld, Germany
• M. Massari, S. Salmaso: Istituto Superiore di Sanità, Italy
• G. Scalia Tomba: University of Rome Tor Vergata, Italy
• M. Sadkowska-Todys, M. Rosinska: National Institute of Hygiene, Poland
• O. Akakakzia, V. Friedrichs: CRP-Santé, Luxembourg
Social Contacts and Mixing Patterns Relevant to the Spread of Infectious Diseases

Joël Mossong¹,², Niel Hens³, Mark Jit⁴, Philippe Beutels⁵, Kari Auranen⁶, Rafael Mikolajczyk⁷, Marco Massari⁸, Stefania Salmaso⁸, Gianpaolo Scalia Tomba⁹, Jacco Wallinga¹⁰, Janneke Heijne¹⁰, Malgorzata Sadkowska-Todys¹¹, Magdalena Rosinska¹¹, W. John Edmunds⁴

¹ Microbiology Unit, Laboratoire National de Santé, Luxembourg, Luxembourg, ² Centre de Recherche Public Santé, Luxembourg, Luxembourg, ³ Center for Statistics, Hasselt University, Diepenbeek, Belgium, ⁴ Modelling and Economics Unit, Health Protection Agency Centre for Infections, London, United Kingdom, ⁵ Unit Health Economic and Modeling Infectious Diseases, Center for the Evaluation of Vaccination, Vaccine & Infectious Disease Institute, University of Antwerp, Antwerp, Belgium, ⁶ Department of Vaccines, National Public Health Institute KTL, Helsinki, Finland, ⁷ School of Public Health, University of Bielefeld, Bielefeld, Germany, ⁸ Istituto Superiore di Sanità, Rome, Italy, ⁹ Department of Mathematics, University of Rome Tor Vergata, Rome, Italy, ¹⁰ Centre for Infectious Disease Control Netherlands, National Institute for Public Health and the Environment, Bilthoven, The Netherlands, ¹¹ National Institute of Hygiene, Warsaw, Poland

Funding: This study formed part of POLYMOD, a European Commission project funded within the Sixth Framework Programme. Contract number: SSP22-CT-2004-502084. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

Academic Editor: Steven Riley, Hong Kong University, Hong Kong

ABSTRACT

Background

Mathematical modelling of infectious diseases transmitted by the respiratory or close-contact route (e.g., pandemic influenza) is increasingly being used to determine the impact of possible interventions. Although mixing patterns are known to be crucial determinants for model outcome, researchers often rely on a priori contact assumptions with little or no empirical basis. We conducted a population-based prospective survey of mixing patterns in eight European countries using a common paper-diary methodology.

Methods and Findings