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Executive summary

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Executive summary

Background

Mathematical models are increasingly used to understand epidemics, to predict future patterns of disease spread, and to plan interventions and responses. Models of epidemic spread rely heavily on the assumptions that they make about patterns of mixing within the population of interest. In recent years, high-quality data have been collected to describe 'normal' patterns of social mixing. However, while such data give good information about healthy individuals, they tell us very little about the behaviour of individuals when they are ill. If, as seems likely, there are significant behavioural changes that take place as a result of illness – such as taking time off work or avoiding social gatherings – we would expect changes in mixing patterns; for predictive models to be effective, they should take into account these changes.

Objectives

- To describe and quantify the changes in social contact behaviour experienced by individuals when they are ill with pandemic H1N1 influenza (swine flu).
- To describe and quantify the changes in mixing patterns of school children that take place as a result of school closures.

Methods

A self-completed questionnaire-based study was designed and carried out in the autumn/winter of 2009–10. The study population was individuals who had been diagnosed with swine flu and who received a swine flu antiviral prescription from an antiviral distribution centre (ADC). The study aimed to quantify changes in participants' social contact behaviour.

The study consisted of two parts: the *initial survey* was designed to be filled in when participants were symptomatic with swine flu; the *follow-up survey* was designed to be filled in once they had recovered. Each part was returned by post in a provided prepaid envelope.

Each part of the questionnaire had two sections.

The first section collected information about the participant (age, sex, household size and composition), their health status (symptoms list, a measure of their current health, date of symptom onset, antiviral use), their behaviour (work/school/college attendance, public transport use), and the impact of their illness on their activities (time off work, receiving care from others). This section also asked participants for their name and address so that the follow-up survey could be sent to them.

The second section was a contact diary in which participants were asked to list all the people they met over the course of a day. A meeting was defined as 'either talking face-to-face or skin-to-skin contact (e.g. a handshake, a kiss, contact sports)'. Participants were asked to give some information about each person whom they reported meeting:

- age (or age range)
- gender
- whether there was skin-to-skin contact (such contacts will be referred to as 'physical' contacts below)
- how long the encounter lasted (participants were asked to tick one of the following: under 5 minutes, 5–10 minutes, 10 minutes to 1 hour, 1–4 hours, over 4 hours)
- where the encounter occurred (participants were asked to tick one or more of the following: home, work/school/college, travel, leisure activity, other)
- how often they normally met this person (participants were asked to tick one of the following: daily or almost daily, once or twice weekly, once or twice monthly, less than monthly, never met before).

Contact diaries contained space for details of 33 contacts to be recorded. Participants were asked whether they had included everyone whom they met during the day and, if not, were asked how many 'additional' people they met.

The follow-up survey was posted to participants approximately 2 weeks after they completed and returned the initial survey; it was hoped that this

time interval would be long enough that most participants would have recovered and resumed their normal activities, but not so long that they would have lost interest in taking part. Those individuals who had not returned their follow-up survey within a further 2 weeks were sent a reminder. Survey forms were coded with a unique identification number that allowed us to match up an individual's initial and follow-up surveys.

The intention was that each participant would record their social contact behaviour once when they were ill with swine flu and once when they had recovered.

A covering letter explaining the purpose of the study and instructions for filling in the forms was included with each survey.

The initial survey was distributed along with antiviral prescriptions at antiviral distribution centres (ADCs) in all parts of England.

Approximately 3800 surveys were distributed by 31 ADCs. Overall, 317 responses to the initial survey were received, and, of these, participants, 179 also returned the follow-up survey.

It was intended that a similar study should take place to look at the impact of swine flu-related school closure on the social contact patterns of school children. However, as swine flu related closures did not occur during the autumn of 2009, this study could not take place. Instead, the methodology was adapted to attempt to quantify the difference in mixing patterns between the school term and the half-term holiday. Eight schools were recruited to take part, and approximately 1100 questionnaire packs were distributed, containing two surveys similar to those described above: one to be filled in during the school term and one during the spring half-term holiday. A total of 134 responses were received, with 119 completed contact diaries.

Results

Swine flu antiviral patient study

We explored changes in each participant's reported contact data. Because of the repeated sampling of participants, we have paired data (i.e. two completed contact diaries) from each participant.

The completed contact diaries contained a great deal of detail about contact behaviour, and there was therefore a multitude of different comparisons that could be attempted; for the sake of simplicity and clarity we restricted ourselves to the following key measures:

- *all* number of contacts listed on the contact diary
- *all plus additional* contacts listed on the contact diary plus any 'additional' contacts
- *physical* total number of physical (skin-to-skin) contacts reported
- *home* total number of home contacts recorded
- *work* total number of work/school/college contacts recorded
- *other* total number of contacts recorded in travel/leisure/other settings
- *long duration* total number of contacts recorded that lasted over 1 hour
- *short duration* total number of contacts recorded that lasted less than 10 minutes
- *frequent* total number of contacts recorded who were encountered once a week or more
- *infrequent* total number of contacts recorded who were encountered less than once a month.

In each case, we sought to explore the extent to which the numbers of these different types of social contacts differed between the initial and the follow-up surveys.

There were indeed noticeable changes in contact behaviour, although contacts taking place at home did not vary. For all types of a contact, except contacts made at home, the differences are highly significant (Wilcoxon signed-rank test, $p < 0.001$). There was no significant change in the number of home contacts.

However, when viewing the sample, and whichever measure of contact we used, we could see that individuals made substantially fewer contacts when they were ill than when they were well. Contacts made by ill participants tended to take place at home (with very few in the workplace or in other settings); they were generally with people whom they met often and for long periods of time, and they often included physical contact.

We postulated that changes in social mixing patterns would be associated with age, gender, changes in health status, returning to work/school/college, household size, and change in day of the week (for instance, from weekday to weekend or vice versa).

These factors were analysed using a linear regression model. Several factors emerge as significant: returning to work/school/college, change in number of symptoms, age and household size.

Returning to work/school/college was associated with a large increased change in the number of contacts reported, being a significant factor in the change in all-plus-additional contacts ($p < 0.001$), all contacts ($p < 0.001$), frequent contacts ($p < 0.001$), long-duration contacts ($p = 0.003$), short-duration contacts ($p = 0.007$), contacts in 'other settings' ($p = 0.013$) and (unsurprisingly) work/school/college contacts ($p < 0.001$).

The change in the number of symptoms reported was also associated with an increased change in numbers of social contacts, being a significant factor in the change in all contacts ($p = 0.022$), infrequent contacts ($p < 0.001$), physical contacts ($p = 0.015$) and short contacts ($p = 0.007$).

Older age was associated with a reduced change in number of contacts: younger adults reported a larger change in their number of infrequent contacts ($p = 0.041$), whereas older adults reported a smaller change in their number of physical contacts ($p = 0.017$ for ages 45–59, $p = 0.034$ for ages over 60) and long-duration contacts ($p = 0.006$ for ages 30–44, $p = 0.002$ for ages 45–59, $p = 0.045$ for ages over 60).

A larger household was associated with a smaller change in the number of infrequent contacts ($p = 0.041$) and physical contacts ($p = 0.032$).

Being infected with diagnosed swine flu had a considerable impact on the social contact patterns of those who participated in our study. Infected participants generally took time away from work/school/college and from social activities, and therefore made considerably fewer contacts when they were ill than when they had recovered. Participants made approximately two-thirds fewer contacts when they were unwell.

The distribution of social contacts changed when people were unwell; unwell people made approximately two-thirds of their social contacts at home, falling to one-quarter when they had recovered, although the reported absolute number of contacts made at home stayed almost constant. Not surprisingly, work/school/college contacts and contacts made in other settings (travel, leisure, other) fell dramatically when people were ill.

There was an observed tendency for the more transient contacts (infrequent contacts and contacts not involving physical contact) to be more influenced by illness than stronger contacts (frequent contacts and physical contacts). This again is unsurprising, as stronger contacts are more likely to be made in the home.

The analysis made clear the important role played by the workplace (or school, or college) on social contacts – returning to work was by some distance the most significant predictor of increased numbers of contacts.

The seriousness of infection also played a role; the greater the change in the number of symptoms reported, the greater the change in the number of contacts.

Differences between age groups emerged, with those in younger age groups tending to have a greater change in their contact patterns; this can be explained by the differences in social mixing patterns between schools and workplaces, with older individuals appearing to mingle in smaller groups than younger individuals.

School closure

A similar paired survey carried out in schools to compare mixing patterns during the half-term holiday with those during school term observed large changes in social contact behaviour. Pupils who completed the survey reported, on average, 18.51 contacts each day during term time and 9.24 during the half-term holiday – a reduction of over 50%. The change in number of contacts was highly significant (Wilcoxon signed-rank test, $p < 0.0001$).

Conclusions

The evidence from this study suggests that ill individuals make substantial changes to their social contact patterns. Participants in the study made substantially fewer social contacts when they were ill compared with when they had recovered. The changes in contact patterns were strongly linked to absence from work and the severity of the reported illness, with age and household size also playing a role. Epidemiological modellers should therefore be wary of using data about 'normal' contact patterns to parameterise mathematical models of disease spread, and should consider the implications of illness-related behavioural changes on model predictions.

This study highlights areas for future research. First, a more detailed study that aims to recruit a representative sample of cases would be particularly valuable; the study here, owing to its

sampling methodology and the time constraints under which it took place, almost certainly ended up with a sample population that was experiencing relatively severe symptoms. Although such people are of interest, they are likely to display greater behavioural change than the average infected case. It would be of value to carry out studies, perhaps during forthcoming seasonal flu seasons, which measure the extent of behavioural change in a broader cross-section of infected cases.

Second, as it was clear that children played a dominant role in the swine flu pandemic, and that they might be expected to do so in future pandemics, and as it was apparent from the UK incidence data that normal patterns of school holidays had a significant impact on transmission, we advocate more detailed studies of the social contact patterns of school children, particularly focusing on differences between school terms and school holidays. Our experience is that for school-based studies to be successful the researcher must be prepared to make a substantial investment of time and energy – such studies are therefore best conceived as long-term projects achieving high levels of engagement with participating schools, rather than as rapid exercises.

Publication

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This themed issue of the *Health Technology Assessment* journal series contains a collection of research commissioned by the NIHR as part of the Department of Health's (DH) response to the H1N1 swine flu pandemic. The NIHR through the NIHR Evaluation Trials and Studies Coordinating Centre (NETSCC) commissioned a number of research projects looking into the treatment and management of H1N1 influenza.

NETSCC managed the pandemic flu research over a very short timescale in two ways. Firstly, it responded to urgent national research priority areas identified by the Scientific Advisory Group in Emergencies (SAGE). Secondly, a call for research proposals to inform policy and patient care in the current influenza pandemic was issued in June 2009. All research proposals went through a process of academic peer review by clinicians and methodologists as well as being reviewed by a specially convened NIHR Flu Commissioning Board.

The final reports from these projects have been peer reviewed by a number of independent expert referees before publication in this journal series.

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Reviews in *Health Technology Assessment* are termed 'systematic' when the account of the search, appraisal and synthesis methods (to minimise biases and random errors) would, in theory, permit the replication of the review by others.

The research reports in this themed issue were funded through the Cochrane Collaboration; the Health Services Research programme (HSR); the Health Technology Assessment programme (HTA); the Policy Research Programme (PRP); and the Service Delivery and Organisation Programme (SDO).

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The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The HTA editors and publisher have tried to ensure the accuracy of the authors' report and would like to thank the referees for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this report. The views expressed in this publication are those of the authors and not necessarily those of the NIHR or the Department of Health.

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