Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebuliser treatment and chest physiotherapy in clinical practice

Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebuliser treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections

AK Simonds,[1]* A Hanak,[1] M Chatwin,[1] MJ Morrell,[1] A Hall,[2] KH Parker,[3] JH Siggers[3] and RJ Dickinson[3]

[1]Clinical and Academic Unit of Sleep & Breathing, Royal Brompton & Harefield NHS Foundation Trust, London, UK
[2]Department of Microbiology, Royal Brompton & Harefield NHS Foundation Trust, London, UK
[3]Department of Bioengineering, Imperial College, London, UK

*Corresponding author

Executive summary

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Executive summary

Background

Influenza viruses are thought to be spread by droplets, but the role of aerosol dissemination (defined as droplet size range < 5 µm) is unclear. A subgroup of patients, often with underlying chronic disorders or risk factors, such as pregnancy or immunosuppression, can develop pneumonia/respiratory insufficiency with H1N1 swine flu or other influenzal infection requiring treatment by oxygen therapy (O2), nebulised medication and ventilatory support. These therapies are thought to generate droplets or aerosols, and in the severe acute respiratory syndrome (SARS) outbreak were associated with an increased incidence of SARS in health-care workers and higher risk of superspreading events in hospital wards. Non-invasive ventilation (NIV) is unlikely to be effective in rapidly progressive acute lung injury, but may have a role in chronic patients in whom influenza has caused an infective exacerbation, and its use may reduce pressure on intensive care beds. Previous studies have not assessed droplet or aerosol generation during respiratory support interventions in clinical practice.

Objectives

We evaluated the characteristics of droplet/aerosol dispersion around delivery systems during NIV, O2, nebuliser treatment and chest physiotherapy by measuring droplet size, geographical distribution of droplets, decay in droplets over time after the interventions were discontinued, and the impact of modification of the NIV circuit in clinical practice.

Methods

Three groups were studied: (1) normal control subjects, (2) subjects with coryzal symptoms and (3) adult patients with chronic lung disease who were admitted to hospital with an infective exacerbation.

Each group received O2, NIV using a vented mask system and a modified circuit with non-vented mask and exhalation filter, and nebulised saline. The patient group had a period of standardised chest physiotherapy treatment. Droplet counts in mean diameter size ranges from 0.3 to > 10 µm were measured with a counter placed adjacent to the face (D1) and at 1-m distance (D2) from subject/patient at the height of the nose/mouth of an average health-care worker.

Results

Non-invasive ventilation using a vented mask produced droplets in the large size range (> 10 µm) in patients ($p = 0.042$) and coryzal subjects ($p = 0.044$) compared with baseline values, but not in normal controls ($p = 0.379$). This increase in large droplets was not seen using the NIV circuit modification. Chest physiotherapy produced droplets predominantly of > 10 µm ($p = 0.003$), which, as with NIV droplet count in the patients, had fallen significantly by 1 m. O2 did not increase droplet count in any size range. Nebulised saline delivered droplets in the small- and medium-size aerosol/droplet range in keeping with the specified performance characteristics of the device but did not increase large-size droplet count. Preliminary analysis suggests that droplet counts fall to within a baseline range within 20–40 minutes of discontinuing the NIV and chest physiotherapy.

Conclusions

Non-invasive ventilation and chest physiotherapy are droplet (not aerosol)-generating procedures, producing droplets of > 10 µm in size. Due to their large mass, most fall out on to local surfaces within 1 m. The only device producing an aerosol was the nebuliser and the output profile is consistent with nebuliser characteristics rather than dissemination of large droplets from patients. These findings suggest that health-care workers providing NIV and chest physiotherapy working within 1 m of an infected patient should have a higher level of respiratory protection, but that infection control measures designed to limit aerosol spread, for example negative-pressure rooms, may have less relevance. The results may have infection control

implications for other airborne infections, such as SARS and tuberculosis, as well as for pandemic influenza infection.

Publication

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The National Institute for Health Research (NIHR) has been established as a part of the Government's strategy, 'Best Research for Best Health'. It provides the framework through which the research staff and research infrastructure of the NHS in England is positioned, maintained and managed as a national research facility.

The NIHR provides the NHS with the support it needs to conduct first-class research funded by the Government and its partners alongside high-quality patient care, education and training. Its aim is to support outstanding individuals (both leaders and collaborators), working in world-class facilities (both NHS and university), conducting leading-edge research focused on the needs of patients.

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); the Public Health Research programme (PHR); and the Service Delivery and Organisation Programme (SDO).

The Cochrane Collaboration is an international not-for-profit and independent organisation, dedicated to making up-to-date, accurate information about the effects of health care readily available worldwide. It produces and disseminates systematic reviews of health-care interventions and promotes the search for evidence in the form of clinical trials and other studies of interventions. Cochrane reviews and the Cochrane Central Register of Controlled Trials are published and updated in *The Cochrane Library* (www.cochranelibrary.com).

The HSR programme aims to lead to an increase in service quality and patient safety through better ways of planning and providing health services. It funds both primary research and evidence syntheses, depending on the availability of existing research and the most appropriate way of responding to important knowledge gaps.

The HTA programme produces high-quality research information on the effectiveness, costs and broader impact of health technologies for those who use, manage and provide care in the NHS. 'Health technologies' are broadly defined as all interventions used to promote health, prevent and treat disease, and improve rehabilitation and long-term care.

The PRP provides the evidence base for policy development on public health and social care issues. It funds research in three main ways: 5-year programmes of research in 16 research units, a primary-care research centre, a public health research consortium, and a surveillance unit; programmes of interlinked studies on key policy initiatives; and single projects and literature reviews.

The PHR programme evaluates public health interventions, providing new knowledge on the benefits, costs, acceptability and wider impacts of non-NHS interventions intended to improve the health of the public and reduce inequalities in health. The scope of the programme is multi-disciplinary and broad, covering a range of interventions that improve public health.

The SDO programme commissions research evidence that improves practice in relation to the organisation and delivery of health care. It also builds research capability and capacity amongst those who manage, organise and deliver services – improving their understanding of the research literature and how to use research evidence.

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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