0.16–2.20 × $10^9$/L (normal 1.06–3.61 × $10^9$/L)]. He developed intermittent watery diarrhoea with persistent detection of norovirus RNA by RT-PCR in stool samples for 18 months, from 28 November 2017 (day 1) to 3 May 2019 (day 522, when the patient succumbed) (Figure 1). Concomitant presence of norovirus RNA in plasma was found on days 493 and 514. The patient deteriorated with nosocomial pneumonia requiring support by continuous positive airway pressure (CPAP) via nasal mask in the intensive care unit from day 514 until he died.

All air samples collected inside the single room and the patient's saliva were positive for norovirus RNA by RT-PCR (Figure 1), but nasopharyngeal aspirates and bronchoalveolar lavage were negative. The corridor, which served as the control sampling point, was negative. Norovirus was detected throughout the entire alimentary tract from the oral cavity (viral load of $7.51\times10^2$ copies/mL) to the rectum (viral load of $4.35\times10^7$ copies/mL) in an immunocompromised host.

Dispersal of airborne norovirus could occur in a debilitated patient with terminal illness when norovirus was detected in saliva, and previously described airborne-norovirus-generating activities (e.g. vomiting, cough, nappy change, toilet flushing and floor cleaning) were absent in this patient. The use of CPAP via a nasal mask may have indirectly facilitated the dispersal of norovirus in bioaerosols in this patient. As mouth breathing is a common problem among CPAP users, norovirus in the oral cavity may have been dispersed to the air through exhalation.

Saliva has been used to monitor norovirus infection in community settings, where the use of a multiplex immunoassay to measure salivary immunoglobulin G responses to the five common norovirus genotypes had sensitivity and specificity of 71% and 96%, respectively, compared with RT-PCR-diagnosed norovirus infection in stool samples [7]. However, saliva has not been used for testing of norovirus RNA by RT-PCR previously, but has now been proven to be possible. In contrast to the contact transmission of norovirus which could be mitigated by enhancement of hand hygiene and environmental cleaning [8], bioaerosol generation may pose an additional risk of nosocomial transmission of norovirus. Further investigation is required to validate the performance of salivary testing in both immunocompetent and immunocompromised patients, and the relationship with bioaerosol generation of norovirus.

**Conflict of interest statement**
None declared.

**Funding sources**
None.

## References

[1] Marks PJ, Vipond IB, Carlisle D, Deakin D, Fey RE, Caul EO. Evidence for airborne transmission of Norwalk-like virus (NLV) in a hotel restaurant. Epidemiol Infect 2000;124:481–7.
[2] Bonifait L, Charlebois R, Vimont A, Turgeon N, Veillette M, Longtin Y, et al. Detection and quantification of airborne norovirus during outbreaks in healthcare facilities. Clin Infect Dis 2015;61:299–304.
[3] Makison Booth C, Frost G. Potential distribution of viable norovirus after simulated vomiting. J Hosp Infect 2019;102:304–10.
[4] Ciofi-Silva CL, Bruna CQM, Carmona RDC, Almeida AGCD, Dos Santos FCP, Inada NM, et al. Norovirus recovery from floors and air after different decontamination protocols. J Hosp Infect 2019;103:328–34.
[5] Cheng VCC, Chen JHK, Wong SCY, Leung SSM, So SYC, Lung DC, et al. Hospital outbreak of pulmonary and cutaneous zygomycosis due to contaminated linen items from substandard laundry. Clin Infect Dis 2016;62:714–21.
[6] Cheng VC, Wong LM, Tai JW, Chan JF, To KK, Li IW, et al. Prevention of nosocomial transmission of norovirus by strategic infection control measures. Infect Control Hosp Epidemiol 2011;32:229–37.
[7] Pisanic N, Ballard SB, Colquechagua FD, François R, Exum N, Yori PP, et al. Minimally invasive saliva testing to monitor norovirus infection in community settings. J Infect Dis 2019;219:1234–42.
[8] Cheng VC, Tai JW, Ho YY, Chan JF. Successful control of norovirus outbreak in an infirmary with the use of alcohol-based hand rub. J Hosp Infect 2009;72:370–1.

V.C.C. Cheng[a,b]
S-C. Wong[b]
K.H.Y. Chiu[a]
C.C.Y. Yip[a]
S.C.Y. Wong[a]
K-Y. Yuen[c,*]
[a]*Department of Microbiology, Queen Mary Hospital, Hong Kong Special Administrative Region, China*
[b]*Infection Control Team, Queen Mary Hospital, Hong Kong West Cluster, Hong Kong Special Administrative Region, China*
[c]*Department of Microbiology, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong Special Administrative Region, China*
* Corresponding author. Address: Department of Microbiology, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong Special Administrative Region, China. Tel.: +852 22552387; fax: +852 28724555.
*E-mail address:* kyyuen@hku.hk (K.-Y. Yuen)

Available online 25 July 2019
https://doi.org/10.1016/j.jhin.2019.07.011



# Lessons learnt from influenza POCT implementation in an acute medical unit

*Sir,*

Influenza point-of-care tests (POCTs) can speed up diagnosis and improve management of patients with influenza [1–3]. Young *et al.* discussed the impact of a POCT for influenza in an emergency department [4]. The POCT was associated with reduced nosocomial transmission of influenza and improved patient flow [4]. We previously reported the impact of a POCT for influenza in an acute medical unit (AMU) [1]. Following the introduction of the POCT, there was an increase in appropriately targeted oseltamivir prescribing, shorter time to isolation, proportionally fewer post-72-h influenza virus cases and

a reduction in length of stay of patients presenting with influenza-like illness [1]. In light of the current situation in Southern Australia, where one of the worst seasons of influenza is being experienced [5], UK hospitals will inevitably look into these systems. Our study was a quality improvement (QI) initiative [1]. The QI methodology used was an amendment of the Institute Healthcare Innovation methodology [6,7]. Reviewing the QI, we identified several challenges.

The first challenge encountered was linking the POCT to the trust's electronic systems. At Queen Elizabeth Hospital Birmingham (QEHB), there is a prescribing, information and communication system (PICS); a rule-based decision support system which operates in all inpatient, outpatient and day case areas, including the AMU. It supports full electronic prescribing and drug administration, requesting and reporting of laboratory investigations, clinical observations and assessments, and extensive order communications, including imaging requests and internal referrals. Within PICS, there is a single infection prevention symbol 'be-aware' for conditions where infection prevention interventions are required. Staff are familiar with the alert and look out for this recognizable symbol. In the QI initiative, the POCT results were not linked to the PICS so required manual input. This was undertaken by the infection prevention team on an ad-hoc basis, resulting in some cases being missed. Without an automated alert, several cases were not flagged on to the PICS. This resulted in the lack of isolation of an influenza-positive patient (mean >2 days vs 0.09 days with the POCT) [1]. In addition, a longer time to oseltamivir prescription was seen for influenza-positive patients (median >2 days vs 0.6 days with the POCT) [1]. An informatic solution, where the be-aware symbol is automatically activated when there is a positive result, will be needed moving forward. For the next influenza season, the QI team will work closely with the POCT team and informatics service to develop a solution.

The second challenge was procurement of the POCT cartridges. During the QI, AMU ran out of POCT cartridges. During this two-week period, 304 fewer tests were undertaken compared with the preceding two weeks when the POCT was used. As a result, patients with influenza in AMU were not identified, resulting in two outbreaks. In total, there were 28 inpatient influenza cases (result >72 h after admission) during this period compared with eight, 10 and nine inpatient influenza cases in December, January and March, respectively, when the POCT was being used. One closed ward had nine positive patients and 13 symptomatic staff. The other closed ward had seven positive patients with no symptomatic staff. The QI team had not correctly predicted the number of cartridges that would be needed. When QEHB tried to order more cartridges, the expense was three times as much as the contracted price. Due to the high expense, approval required senior management, which was protracted, and the cartridges took over two weeks to be delivered. For the next influenza season, a larger number of POCT cartridges will be ordered and stored in an off-site pharmacy warehouse to facilitate accessibility when new stocks are required.

The third challenge encountered was clinical staff becoming over reliant on the POCT. When cartridges ran out, the clinicians often failed to consider influenza in their differential diagnoses. Patients with influenza were not diagnosed and were transferred to wards, resulting in both bay and ward closures. Important points to consider here are human factors and the fact that an available test can de-skill clinical staff in diagnosing influenza. The QI team neglected to consider undertaking a 'bullet proofing' technique when implementing the QI project. Alderick (2017) stated that it is important in QI to plan and prepare for things that could go wrong [8] The experience has highlighted to us the importance of providing continuous education sessions on the management of influenza for clinical staff during subsequent influenza seasons.

There are numerous research articles showing that QI methodology can be used to reduce healthcare-associated infections and improve patient outcomes [6]. We have demonstrated that QI can be used to improve the management of patients with influenza. We have also detailed a number of challenges we faced, and hope that other hospitals can learn from our experience when implementing a POCT for influenza.

## Acknowledgements

We would like to thank the Infection Prevention and Control Team, staff on the AMU and the POCT Team at QEHB, University Hospitals Birmingham NHS Foundation Trust.

**Conflict of interest statement**
None declared.

**Funding sources**
None.

## References

[1] Garvey MI, Wilkinson MAC, Bradley CW, Biggs M, Reddy-Kolanu V, Osman H, et al. Impact of a PCR point of care test for influenza A/B on an acute medical unit in a large UK teaching hospital: results of an observational, pre and post intervention study. Antimicrob Resist Infect Control 2019;8:120.

[2] Lowe CF, Leung V, Karakas L, Merrick L, Lawson T, Romney MG, et al. Targeted management of influenza A/B outbreaks incorporating the cobas® influenza A/B & RSV into the virology laboratory. J Hosp Infect 2019;101:38—41.

[3] Public Health England. Point of care tests for influenza and other respiratory viruses. London: PHE; 2018. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/762344/point_of_care_tests_for_influenza_and_other_respiratory_viruses.pdf [last accessed February 2019].

[4] Youngs J, Iqbal Y, Glass S, Riley P, Pope C, Planche T, et al. Implementation of the cobas® Liat® influenza point-of-care-test into an emergency department during a high-incidence season: a retrospective evaluation following real-world implementation. J Hosp Infect 2018;101:285—8.

[5] Australian Government Department of Health. Australian influenza surveillance report updates. Available at: https://www1.health.gov.au/internet/main/publishing.nsf/Content/cda-surveil-ozflu-flucurr.htm [last accessed August 2019].

[6] Adams D, Hine V, Bucior H, Foster W, Mukombe N, Ryan J, et al. Quality improvement collaborative: a novel approach to improve infection prevention and control. Perceptions of lead infection prevention nurses who participated. J Infect Prev 2018;19:64—71.

[7] Institute of Healthcare Improvement. The Breakthrough Series: IHI's collaborative model for achieving breakthrough improvement. Boston, MA: IHI Innovation Series white paper; 2003.

[8] Alderwick H, Charles A, Jones B, Warburton W. Making the case for quality improvement: lessons for NHS boards and leaders. London:

The King's Fund; 2017. Available at: https://www.kingsfund.org.uk/publications/making-case-quality-improvement [last accessed April 2019].

M.I. Garvey[a,b,*]
M. Biggs[a]
V. Reddy-Kolanu[a]
H. Flavell[a]
A. Wallett[a]
E. Holden[a]
[a]*University Hospitals Birmingham NHS Foundation Trust, Queen Elizabeth Hospital Birmingham, Edgbaston, Birmingham, UK*
[b]*Institute of Microbiology and Infection, The University of Birmingham, Edgbaston, Birmingham, UK*

* Corresponding author. Address: University Hospitals Birmingham NHS Foundation Trust, Queen Elizabeth Hospital Birmingham, Edgbaston, Birmingham B15 2WB, UK. Tel.: +44 (0)121 371 3787.
*E-mail addresses:* mark.garvey@uhb.nhs.uk, m.i.garvey@bham.ac.uk (M.I. Garvey)

Available online 6 August 2019

https://doi.org/10.1016/j.jhin.2019.08.003



## Seasonal respiratory virus testing in management of adult cystic fibrosis patients

*Sir,*

Testing for respiratory virus infections (RVIs) is performed less frequently in patients with cystic fibrosis (CF), although they are known to contribute to bacterial infections and exacerbations by various mechanisms [1–3]. Thus, routine screening for such viruses may enhance the management of these patients [4]. Here we describe the incidence of RVIs over one season in our adult CF patients.

Between February 2016 and March 2017, there were two consecutive seasonal influenza outbreaks on our adult respiratory and CF patient ward. This prompted a PDSA (Plan, Do, Study, Act) quality service improvement evaluation to assess the utility of routine respiratory virus testing in the management of adult CF patients during a respiratory exacerbation. This had several aims, including: earlier RVI detection, early targeted antiviral treatment (for influenza alone), checking vaccination history and correlation with the test result (for influenza alone), and exploring the possible role of occupation in the exposure and acquisition of RVIs.

Routine screening for seasonal RVIs for all adult CF patients took place between November 2017 and April 2018. Respiratory virus swabs were taken by the CF nurses from all inpatients, ward attenders and outpatients with CF, and sent to the diagnostic laboratory for testing using a commercial respiratory virus multiplex polymerase chain reaction assay.

Of 37 adult CF patients presenting with an exacerbation, 13 had an RVI and 11 had more than one exacerbation. Of the 11 patients with more than one exacerbation, four were diagnosed with an RVI during one of these encounters. Of the 13 patients with an RVI, nine had non-influenza infections (two entero-/rhinoviruses, five NL63 and one HKU1 coronaviruses, one human metapneumovirus), three had influenza infections alone (two influenza A/H3N2, one influenza B), and one was multiply infected with influenza B, corona- OC43 and entero-/rhinoviruses.

Of the nine patients infected with non-influenza viruses, four were treated empirically with oseltamivir (one commenced oseltamivir treatment but did not complete the course, two completed oseltamivir treatment, one received post-exposure prophylactic oseltamivir). All four patients with laboratory-confirmed influenza received oseltamivir treatment.

Of the 24 patients who had no detectable RVI, one had commenced oseltamivir treatment empirically but did not complete the course, and four had completed oseltamivir treatment. Symptomatic cases were more likely to have been prescribed empirical oseltamivir treatment than asymptomatic cases, as per local seasonal influenza clinical guidelines.

Regarding influenza vaccination history, 24 of 37 patients had no detectable RVI, of whom 19 had been vaccinated against influenza in the preceding six months. Of the five unvaccinated patients, when asked why they had not attended for vaccination, one was unconcerned, three could not access the vaccine, and one had become unwell post vaccination in a previous season so had declined vaccination this season.

Of the four patients who had laboratory-confirmed influenza, three were not vaccinated due to a lack of concern and one had been vaccinated earlier in the season but became infected with late-season influenza. A history of influenza vaccination was found to be significantly higher ($P<0.05$) in the RVI-negative cases, indicating that this was a protective intervention.

We also investigated whether these adult CF patients had occupations that put them in frequent contact with potentially respiratory-virus-infected people. Of the 13 patients with a laboratory-confirmed RVI, six were unemployed, one worked from home and six worked in occupations with frequent public interactions. Of the 24 patients without any RVIs, 17 worked in occupations with regular public contact, five were unemployed, one was at college (with frequent contact with other students) and one worked from home. No significant ($P>0.4$) differences were identified between occupational status and positive or negative RVI status.

In summary, routine RVI screening allowed early influenza and non-influenza virus detection in 11% and 24% of patients, respectively. Early RVI detection allows the prompt treatment of any influenza cases, reducing the potential severity of possible secondary bacterial infective exacerbations. It also enables the timely implementation of appropriate infection control measures.

Influenza vaccination appears to be effective in reducing the risk of developing influenza virus infection, although this could be improved further with enhanced patient education