Carbon Dioxide monitoring whilst ringing

Rationale

For the safe and sustainable continuation of ringing in this virus age, it will be very useful to investigate the differences of ventilation in ringing chambers. This will not be relevant for the forthcoming return of ringing on 17/5 and 21/6, (which is predicated on low virus levels and high uptake of a vaccine which is effective against current variants); but is likely to be highly relevant in the autumn when virus levels rise again.

With improved understanding of the means of transmission of Covid-19, it has become clear how important good ventilation is in reducing virus transmission – by dispersing viruses present in aerosol particles.[1] [2] [3] [4] There are now at least two objective tools for calculating Coronavirus transmission risks in indoor spaces, which include ventilation within their weighting criteria, (along with mask wearing, activity levels, viral prevalence in the community etc).[5] [6]

If, as is being predicted by scientists, transmission of Coronavirus rises later in the year, we want to be able to keep well-ventilated towers ringing (by demonstrating objectively that they are at low risk of virus transmission), rather than needing to have a blanket ban as in 2020. The current low incidence of virus transmission and vaccine efficacy provides an opportunity to gather information which will stand us in good stead when new variants arrive which are not protected against by the current vaccines, and transmission rises again.

CO_2 levels are an adequate and simple proxy, which take account not only of how much virus an infectious person is emitting (proportionate to how heavily they are breathing) but also whether that virus aerosol builds up (in poorly ventilated spaces) or is dispersed harmlessly (in well ventilated spaces). "...a significant amount of bio-aerosol expelled during exhalation can remain airborne and be carried around the building by the ventilation flow. Since carbon dioxide is also exhaled and carried by the ventilation flow we propose that concentration levels of CO_2 can be used to indicate the potential presence of SARS-CoV-2 in the air, and that high levels should trigger remedial action to reduce the risk of infection." [7] (See also "Readme" in footnote 3). CO_2 measurement has long been the industry standard for assessing the adequacy of ventilation and is appropriate for use in towers.

Equipment

A Non-dispersive Infra Red (NDIR) Carbon Dioxide sensor is needed. There are a wide number of these devices on the market. Ideally one should be used which has the facility to be set working and then independently record levels for later analysis, rather than one that only has a real-time display (which would necessitate having another person in the room).

These devices are not cheap, but would not be needed by every tower, and so may best be bought as an Association / Guild resource for sharing.

Two examples are: https://www.dracal.com/store/products/usb_dxc100/index.php (which needs to be attached to a computer, but which comes with software for logging and graph production, and has a large font real time screen display facility), and https://aranet4.com/?gclid=CjwKCAjwj6SEBhAOEiwAvFRuKE3ot_SRkonMOFJcsew4OI2Ph_ImupBcGAsNDaBPJS5RYRSO5yB0txoCaB4QAvD_BwE which is stand-alone and controlled via a smartphone app. (I have no personal experience of using this, but it is recommended by the writer of one of the risk calculation tools; since we left the EU it has become difficult to source).

eCO_2 sensors (or '*equivalent CO_2*' sensors) should not be used. These devices can only measure volatile organic compounds (VOCs) and make an estimate of CO_2 concentration based on the concentration of VOCs in the air. They do not directly measure the indoor CO_2 concentration.

Method

Both "Pragmatic" and "Air-changes-per-hour" methods are possible.

A pragmatic way of testing ventilation (during this time when community viral levels are low and vaccine efficacy high) is to monitor CO_2 levels during ringing by a band of low risk individuals, and check that they don't rise too high.

Outside fresh air:	350 – 450 ppm
Desirable maximum indoor levels:	800 – 1000 ppm

(Authorities differ, lower level felt to be more appropriate where occupants are exerting themselves)

Agreed cut off level where ventilation is inadequate:	1500 ppm

Monitoring should take place at 5 – 6 feet above floor level (held, for example, by a camera tripod or the rope spider). It should not be in the direct line of draughts, but in an area or areas which represents best where ringers will be standing.

So a band could ring and record what happens to the CO_2 level in a number of different circumstances (variable sensor location within the chamber, duration of ringing, number of ringers, Heavy or Light 6, windows and door open or closed, effect of getting everyone to vacate the room for 15 minutes then return, what setting the tower ventilation system is run at).

Having undertaken this, a band should have a good idea whether they have adequate ventilation and for which types of ringing; this is likely to be sufficient for most towers. This has the advantage of simplicity and modelling *exactly* the activity for which the room will be used, but what this does

not give is a neat number (Air changes per hour) to put into the risk calculators mentioned in footnotes 3 and 4.

Air-changes-per-hour (ACH). To calculate this, the unoccupied room needs to have the CO2 level raised substantially above that of outside air, then the level monitored to see how it drops towards the outside level. At this footnote there is a link to a paper explaining one method.[8]

In short, $\mathrm{ACH} = \frac{1}{\text{time in hours for CO2 level to drop by 63\% of excess above outside levels}}$

To achieve this, a source of CO_2 is needed. This could be by letting off an out of date CO_2 fire extinguisher, a sodastream, from a cylinder supplied by your pub landlord, or getting someone to work out on an exercise bike. Please note that high levels of CO2 are dangerous, potentially fatal, and particularly if adding large amounts to a closed room from a cylinder. Any addition should be made from the doorway in exiting the room, after setting up the monitor. After the measurement time has passed, the room should be re-ventilated, by opening the door widely and waiting, before re-entering. Never attempt to create CO2 by combustion inside a room, because of the danger of producing the very dangerous Carbon Monoxide.

Having calculated the ACH, the number can then be inputted into the risk calculator. The downside of this method is that the calculators also need you to input an estimate for the exertion of the ringers (and therefore CO_2 generation), and your estimate may be inaccurate. However such a calculator is likely to be able to give a fair idea of how long a given number of people will be safe to ring, in a variety of circumstances.

Results

The results from testing are likely to be as disparate as are the towers in which we ring and the circumstances in which they were tested. The outcome from a 30 minute pre-service ring is likely to be very different from a 90 minute practice evening with 15 people crammed into a 6 bell tower.

With many it is likely that testing will give speedy reassurance to the band and “venue manager” (incumbent, PCC, Chapter etc) that ventilation is good. Some borderline cases may wish to move on from pragmatic to ACH testing to give greater clarity. In some cases ventilation will be poor and need to be improved.

This use of CO_2 monitoring in towers is a new activity, and we will have lots to learn from each other – both from some of you who come from an engineering (perhaps even ventilation?) background, and also those of you who have just performed some simple tests whilst ringing in your tower. It would be helpful if you could forward your thoughts, experience and results to David Pouncey david@dacgp.plus.com so that they can be collated.

Consequent Actions

Ensuring sufficient ventilation in towers will have long lasting benefits, as aerosol transmission is significant in the spread of many common infectious diseases. CO_2 monitoring gives an objective starting point for identifying whether action should be taken, whether it is effective, and indeed whether it is necessary (i.e. do the windows really need to be open in the depth of winter?!). Often simple measures (such as the opening of existing windows and vents) will improve the situation sufficiently for ventilation to be adequate. However if more complicated and expensive action is needed, with faculties, listed building consent, etc, CO_2 monitoring gives a very sound basis from which to start.

Dr David Pouncey

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[1] https://www.gov.uk/government/publications/emg-role-of-ventilation-in-controlling-sars-cov-2-transmission-30-september-2020

[2] https://go.cibse.org/l/698403/2020-10-24/3bvyrx/698403/1603540438B53rOzcU/Covid_19_Ventilation_guidance_v4.pdf

[3] Covid-19 has redefined airborne transmission

[4] Roadmap to improve and ensure good indoor ventilation in the context of COVID-19

[5] https://tinyurl.com/covid-estimator

[6] https://indoor-covid-safety.herokuapp.com/apps/advanced?units=metric

[7] https://www.cambridge.org/core/journals/journal-of-fluid-mechanics/article/effects-of-ventilation-on-the-indoor-spread-of-covid19/CF272DAD7C27DC44F6A9393B0519CAE3#articleevel of breathing)

[8] https://medium.com/@jjose_19945/how-to-quantify-the-ventilation-rate-of-an-indoor-space-using-a-cheap-co2-monitor-4d8b6d4dab44