

# S1 Text: Direct estimates of absolute ventilation rates in primary level clinics in South Africa

## Supplementary Tables

Table A: Differences between the two methods used to measure ventilation in the clinics

| Name of method                 | Brief description of method  | Room conditions in which experiments performed | Occupancy of space at time of experiment  | Rooms in which experiments were performed in                                | Advantages                             | Disadvantages   |
|--------------------------------|--|--|---|---|--|---|
| Tracer gas release experiments | CO <sub>2</sub> was used as the tracer gas for this method. CO <sub>2</sub> was released. The windows and doors were opened and the decay of the CO <sub>2</sub> was measured. | Ideal and usual conditions                     | Rooms had no HCWs or patients in the room | Mainly small spaces where a high CO <sub>2</sub> baseline could be achieved | Gold standard                          | CO <sub>2</sub> is released into the atmosphere<br><br>Difficult to measure large spaces with this method<br><br>Difficult to perform during work hours in areas with a large occupancy |
| Rebreathed fraction approach   | CO <sub>2</sub> levels were measured every second in three inside sites of the waiting room and at one site outside of the building. Headcounts were performed.                | Ideal and usual conditions                     | Rooms were occupied by HCWs and patients  | Main waiting rooms  | Can be performed during working hours. | Headcounts were performed every 10 minutes. The waiting rooms were very dynamic so the variations of CO <sub>2</sub> produced by the number of people may not have been captured        |

CO<sub>2</sub>: Carbon dioxide HCW: healthcare workers

Table B: Definitions of Usual and Ideal conditions

| <b>Term</b>      | <b>Description</b>   |
|------------------|--|
| Usual conditions | The configuration of the existing windows and doors in the room observed on the day of room volume measurements (in the case of the tracer gas release experiments); or<br>The configuration of the existing windows and doors found when in use (in the case of the rebreathed fraction approach) |
| Ideal conditions | All windows and doors fully opened to allow for maximal ventilation  |

Table C: Absolute ventilation rates of the clinic spaces under usual and ideal conditions using the tracer gas release technique

| Clinic | Room     | Use of room     | Room volume (m <sup>3</sup> ) | ACH under usual conditions (95% CI) | Absolute ventilation rate in m <sup>3</sup> /hr under usual conditions (95% CI) | ACH under ideal conditions (95% CI) | Absolute ventilation rate in m <sup>3</sup> /hr under ideal conditions (95% CI) | Fold increase in ventilation rate (ideal/usual) |
|--------|----------|-----------------|-------------------------------|-------------------------------------|---|-------------------------------------|---|---|
| WC1    | Room CR3 | Consulting room | 30.9                          | 1.7 (1.1 – 2.3)                     | 52.4 (34.6 – 70.3)  | 15.8 (12.4 – 19.2)                  | 489.4 (384.7 – 594.2)   | 9.3   |
| WC2    | Room CR  | Consulting room | 29.4                          | 2.1 (1.4 – 2.8)                     | 62.0 (40.7 – 83.4)  | 54.0 (44.8 – 63.2)                  | 1586.5 (1316.3 – 1856.7)  | 25.6  |
| WC3    | Room D   | Consulting      | 22.4                          | 0                                   | 0   | 14.7 (12.4 – 17.1)                  | 329.7 (277.5 – 381.9)   | *   |
| WC3    | Room G   | Waiting room    | 31.3                          | 26.5 (18.0 – 34.9)                  | 827.6 (563.6 – 1091.5)  | 26.5 (18.0 – 34.9)                  | 827.6 (563.6 – 1091.5)  | 1   |
| WC3    | Room H   | Consulting room | 45.5                          | 31.9 (25.9 – 38.0)                  | 1451.5 (1176.0 – 1726.9)  | 34.1 (28.4 – 39.8)                  | 1550.3 (1289.3 – 1811.3)  | 1.1   |
| WC3    | Room J   | Consulting room | 22.1                          | 9.7 (8.5 – 10.8)                    | 213.4 (188.4 – 238.3)   | 29.5 (17.3 – 41.7)                  | 651.5 (381.5 – 921.5)   | 3.1   |
| WC5    | Room A   | Consulting room | 32.9                          | 3.91 (2.4 – 5.5)                    | 128.5 (79.2 – 177.9)  | 7.2 (5.3 – 9.1)                     | 237.4 (175.1 – 299.6)   | 1.9   |
| WC6    | Room PD  | Waiting area    | 54.3                          | 36.18 (27.2 – 45.2)                 | 1962.9 (1476.4 – 2449.5)  | 65.2 (53.5 – 76.8)                  | 3535.1 (2901.9 – 4168.3)  | 1.8   |
| WC6    | Room TB  | Waiting area    | 81.0                          | 32.74 (29.2 – 36.3)                 | 2651.0 (2364.5 – 2937.4)  | 36.1 (25.7 – 46.5)                  | 2923.2 (2081.7 – 3764.6)  | 1.1   |
| KZN1   | Room CD  | Vitals          | 16.7                          | 3.47 (3.1 – 3.9)                    | 58.03 (51.3 – 64.7)   | 23.4 (18.2 – 28.6)                  | 391.3 (303.7 – 478.8)   | 6.7   |
| KZN1   | Room CI  | Consulting      | 20.8                          | 17.3 (15.0 – 19.7)                  | 360.4 (311.7 – 409.2)   | 25.4 (22.3 – 28.6)                  | 528.6 (463.0 – 594.2)   | 1.5   |
| KZN1   | Room ME  | Consulting      | 20.7                          | 3.1 (1.2 – 5.01)                    | 63.3 (22.9 – 103.8)   | 13.2 (12.6 – 13.8)                  | 273.0 (261.4 – 284.7)   | 4.3   |
| KZN1   | Room MF  | Consulting      | 32.8                          | 15.1 (14.2 – 15.9)                  | 493.81 (466.3 – 521.4)  | 18.8 (17.4 – 20.2)                  | 614.8 (568.4 – 661.1)   | 1.3   |

|      |           |                          |       |                    |                          |                    |                          |      |
|------|-----------|--------------------------|-------|--------------------|--------------------------|--------------------|--------------------------|------|
| KZN2 | Room A    | Waiting area             | 135.4 | 14.6 (12.0 – 17.1) | 1972.7 (1628.0 – 2317.3) | 24.2 (18.6 – 29.8) | 3273.2 (2511.3 – 4035.2) | 1.7  |
| KZN2 | Room C    | Vitals                   | 42.7  | 22.3 (20.8 – 23.7) | 949.92 (888.0 – 1011.8)  | 24.3 (23.3 – 25.3) | 1036.7 (995.4 – 1077.9)  | 1.1  |
| KZN2 | Room HI   | Consulting               | 34.6  | 6.4 (3.6 – 9.3)    | 222.7 (124.6 – 320.7)    | 26.9 (23.0 – 30.8) | 930.3 (794.2 – 1066.4)   | 4.2  |
| KZN2 | Room K    | Waiting area             | 79.6  | 4.25 (3.2 – 5.3 )  | 338.0 (253.8 – 422.3)    | 15.7 (11.5 – 20.0) | 1252.8 (917.1 – 1588.4)  | 3.7  |
| KZN2 | Room M    | Consulting               | 44.8  | 4.4 (4.0 – 4.8)    | 197.4 (179.0 – 215.8)    | 26.3 (23.6 – 29.1) | 1179.3 (1056.7 – 1302.0) | 6.0  |
| KZN2 | Room S    | Consulting               | 14.7  | 1.2 (0.8 – 1.7)    | 18.3 (11.5 – 25.1)       | 26.7 (23.2 – 30.2) | 392.0 (339.9- 444.0)     | 21.5 |
| KZN2 | Room V    | Corridor inside          | 53.4  | 25.0 (19.7 – 30.4) | 1337.1 (1051.2 – 1622.9) | 32.6 (19.4 – 45.9) | 1743.7 (1035.9 – 2451.6) | 1.3  |
| KZN3 | Room HAST | Waiting area             | 106.4 | 21.1 (17.8 – 24.3) | 2240.3 (1894.2 – 2586.4) | 29.3 (26.7 – 32.0) | 3119.7 (2839.6 – 3399.8) | 1.4  |
| KZN3 | Room TB   | Waiting area             | 28.1  | 9.1 (7.9 – 10.3)   | 255.4 (220.9 – 289.9)    | 27.7 (23.2 – 32.2) | 7778.5 (652.0 – 905.0)   | 3.1  |
| KZN4 | Area L    | Main indoor waiting area | 50.2  | 25.7 (23.0 – 28.4) | 1289.4 (1156.0 – 1422.7) | 40.3 (34.3 – 46.4) | 2023.7 (1719.1 – 2328.3) | 1.6  |
| KZN4 | Space STU | Bloods room              | 51.8  | 7.7 (6.6 – 8.9)    | 400.3 (342.2 – 458.5)    | 18.1 (15.3 – 20.9) | 937.0 (792.0 – 1081.9)   | 2.3  |
| KZN6 | Room KJ   | Waiting area             | 68.3  | 13.7 (12.1 – 15.3) | 936.9 (826.9 – 1046.9)   | 43.6 (39.4 – 47.7) | 2976.7 (2692.9 – 3260.4) | 3.2  |
| KZN6 | Room N    | Consulting room          | 35.5  | 20.4 (20.0 – 20.7) | 723.7 (710.5 – 736.9)    | 27.7 (26.3 – 29.2) | 985.5 (933.7 – 1037.3)   | 1.4  |

\*Unable to calculate fold increase as ACH under usual conditions was 0.

Table D: Ventilation rates using the rebreathed fraction approach using continuous measurements under usual and ideal conditions

| Clinic | Room     | Volume of room (m <sup>3</sup> ) | ACH under usual conditions (95% CI) | Absolute ventilation rate in m <sup>3</sup> /hr under usual conditions (95% CI) | ACH under ideal conditions (95% CI) | Absolute ventilation rate in m <sup>3</sup> /hr under ideal conditions (95% CI) | Fold increase in ventilation (ideal/usual) |
|--------|----------|----------------------------------|-------------------------------------|---|-------------------------------------|---|--|
| WC1    | Room WA2 | 509.6                            | 3.1<br>(2.4 – 3.7)                  | 1572.2<br>(1238.7 – 1905.6)   | 13.7<br>(9.5 – 18.0)                | 6986.8<br>(4821.6 – 9152.0)   | 4.4  |
|        | Room WA4 | 157.3                            | 9.1<br>(6.1 – 12.1)                 | 1436.9<br>(963.4 – 1910.5)  | 59.3<br>(36.0 – 82.6)               | 9328.4<br>(5665.7 – 12991.0)  | 6.5  |
| WC2    | Room WA1 | 213.9                            | 3.3<br>(2.4 – 4.2)                  | 701.5<br>(507.5 – 895.4)  | 8.7<br>(5.9 – 11.6)                 | 1870.3<br>(1264.5 – 2476.2)   | 2.7  |
| WC3    | Room X   | 549.0                            | 4.4<br>(3.9 – 4.9)                  | 2391.5<br>(2210.9 – 2672.0)   | 4.4<br>(3.8 – 4.9)                  | 2391.5<br>(2210.9 – 2672.0)   | 1  |
| WC5    | Room E   | 2147.3                           | 2.1<br>(1.9 – 2.3)                  | 4470.3<br>(4007.5 – 4933.0)   | 2.5<br>(2.2 – 2.9)                  | 5458.8<br>(4664.1 – 6253.5)   | 1.2  |
| KZN1   | Room MA  | 226.7                            | 21.2<br>(19.2 – 23.3)               | 4815.1<br>(4348.4 – 5281.9)   | 24.1<br>(17.4 – 30.8)               | 5454.6<br>(3933.1 – 6976.2)   | 1.1  |
| KZN3   | Room U   | 458.7                            | 4.6<br>(4.0 – 5.2)                  | 2116.9<br>(1834.7 – 2399.2)   | 6.1<br>(4.7 – 7.4)                  | 2782.0<br>(2155.8 – 3408.3)   | 1.3  |
| KZN4   | Space L  | 50.2                             | 33.5<br>(28.5 – 38.5)               | 1680.59<br>(1431.1 – 1930.1)  | 107.2<br>(83.2 – 131.3)             | 5381.1<br>(4172.9 – 6589.2)   | 3.2  |

Table E: Risk of Mycobacterium tuberculosis infection for a healthcare worker spending 15 minutes per day for 25 working days with an infectious individual, calculated using the Wells-Riley equation. The probability of infection was calculated separately for each space using the measured absolute ventilation rates under usual and ideal conditions. We calculated risk using both a standard assumption about infectiousness (1.25 quanta/hr) and using a higher estimate taken from the published literature (8.2 quanta/hr).

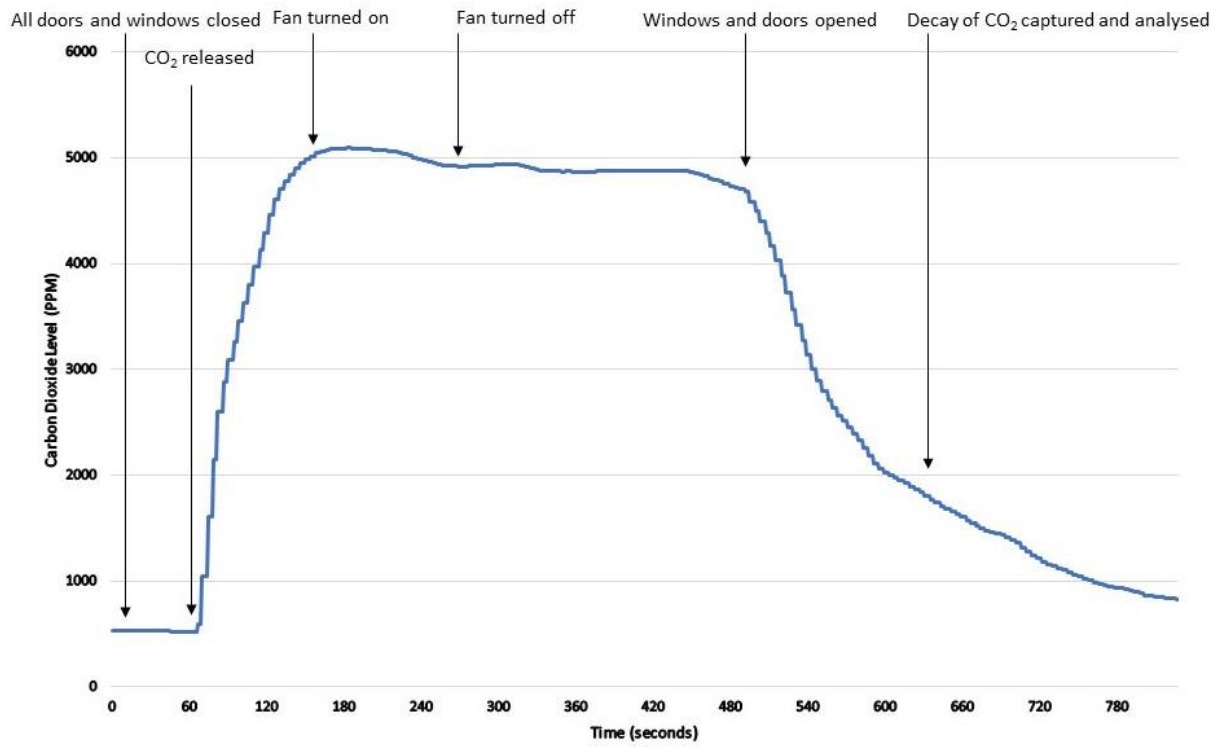
| Facility | Method used to calculate absolute ventilation rates | Consulting room | Risk of becoming infected (1.25 q/hr, usual conditions) (%) | Risk of becoming infected (1.25 q/hr, ideal conditions) (%) | Risk of becoming infected (8.2 q/hr, usual conditions) (%) | Risk of becoming infected (8.2 q/hr, ideal conditions) (%) |
|----------|---|-----------------|---|---|--|--|
| WC1      | Tracer gas release                                  | Room CR3        | 8.6   | 1.0   | 44.4   | 6.1  |
| WC2      | Tracer gas release                                  | Room CR         | 7.2   | 0.3   | 39.1   | 1.9  |
| WC3      | Tracer gas release                                  | Room D          | 100   | 1.4   | 100  | 8.9  |
| WC3      | Tracer gas release                                  | Room H          | 0.3   | 0.3   | 2.1  | 2.0  |
| WC3      | Tracer gas release                                  | Room J          | 2.2   | 0.7   | 13.4   | 4.6  |
| WC5      | Tracer gas release                                  | Room A          | 3.6   | 2.0   | 21.3   | 12.2   |
| KZN1     | Tracer gas release                                  | Room CI         | 1.3   | 0.9   | 8.2  | 5.7  |
| KZN1     | Tracer gas release                                  | Room ME         | 7.1   | 1.7   | 38.5   | 10.7   |
| KZN1     | Tracer gas release                                  | Room MF         | 0.9   | 0.8   | 6.0  | 4.9  |
| KZN2     | Tracer gas release                                  | Room HI         | 2.1   | 0.5   | 12.9   | 3.3  |
| KZN2     | Tracer gas release                                  | Room M          | 2.3   | 0.4   | 14.4   | 2.6  |
| KZN2     | Tracer gas release                                  | Room S          | 22.6  | 1.2   | 81.4   | 7.5  |
| KZN6     | Tracer gas release                                  | Room N          | 0.6   | 0.5   | 4.2  | 3.1  |

Table F: Risk of Mycobacterium tuberculosis infection for a patient spending 2.5 hours in a waiting room with an infectious individual, calculated using the Wells-Riley equation. The probability of infection was calculated separately for each space, using the measured absolute ventilation rates under usual and ideal conditions. We used both a standard assumption about infectiousness (1.25 quanta/hr) plus two higher estimates from the published literature (8.2 quanta/hr and 226 quanta/hr).

| Clinic | Method used to calculate absolute ventilation rates | Waiting room | Risk of becoming infected (1.25 q/hr, usual conditions) (%) | Risk of becoming infected (1.25 q/hr, ideal conditions) (%) | Risk of becoming infected (8.2 q/hr, usual conditions) (%) | Risk of becoming infected (8.2 q/hr, ideal conditions) (%) | Risk of becoming infected (226 q/hr, usual conditions) (%) | Risk of becoming infected (226 q/hr, ideal conditions) (%) |
|--------|---|--------------|---|---|--|--|--|--|
| WC1    | Rebreathed fraction                                 | Room WA2     | 0.1   | 0.03  | 0.8  | 0.2  | 19.4   | 4.7  |
|        | Rebreathed fraction                                 | Room WA4     | 0.1   | 0.02  | 0.9  | 0.1  | 21.0   | 3.6  |
| WC2    | Rebreathed fraction                                 | Room WA1     | 0.3   | 0.1   | 1.7  | 0.7  | 38.3   | 16.6   |
| WC3    | Rebreathed fraction                                 | Room X       | 0.08  | 0.1   | 0.5  | 0.5  | 13.2   | 13.2   |
| WC5    | Rebreathed fraction                                 | Room E       | 0.04  | 0.03  | 0.3  | 0.2  | 7.3  | 6.0  |
| KZN1   | Rebreathed fraction                                 | Room MA      | 0.04  | 0.03  | 0.3  | 0.2  | 6.8  | 6.0  |
| KZN3   | Rebreathed fraction                                 | Room U       | 0.1   | 0.1   | 0.6  | 0.4  | 14.0   | 11.5   |
| WC3    | Tracer gas release                                  | Room G       | 0.2   | 0.2   | 1.5  | 1.5  | 33.6   | 33.6   |
| WC6    | Tracer gas release                                  | Room PD      | 0.1   | 0.1   | 0.6  | 0.3  | 15.9   | 9.1  |
| WC6    | Tracer gas release                                  | Room TB      | 0.1   | 0.1   | 0.5  | 0.7  | 12.0   | 10.9   |
| KZN2   | Tracer gas release                                  | Room A       | 0.1   | 0.1   | 0.6  | 0.4  | 15.8   | 9.8  |
| KZN2   | Tracer gas release                                  | Room K       | 0.6   | 0.1   | 3.6  | 1.0  | 63.3   | 23.7   |
| KZN3   | Tracer gas release                                  | Room HAST    | 0.3   | 0.1   | 0.5  | 0.4  | 14.0   | 10.3   |
| KNZ3   | Tracer gas release                                  | Room TB      | 0.1   | 0.1   | 2.3  | 0.7  | 46.7   | 18.7   |
| KZN4   | Tracer gas release                                  | Area L       | 0.1   | 0.1   | 0.9  | 0.6  | 23.1   | 15.4   |
| KZN6   | Tracer gas release                                  | Room KJ      | 0.2   | 0.1   | 1.3  | 0.4  | 30.4   | 10.8   |

# Figures

Fig A: An example of a tracer gas release experiment from Room C at KZN2 clinic (experiment 6 Monitor A). Following log transformation, the right hand side of the curve is approximately linear.



CO<sub>2</sub>: carbon dioxide; PPM: parts per million



Fig B: Histograms showing the distribution of temperatures and wind speeds in KwaZulu-Natal and Western Cape during working hours from January 2018 - December 2020. Vertical lines shows the mean temperatures and wind speeds on the 8 days when the rebreathed approach experiments were conducted

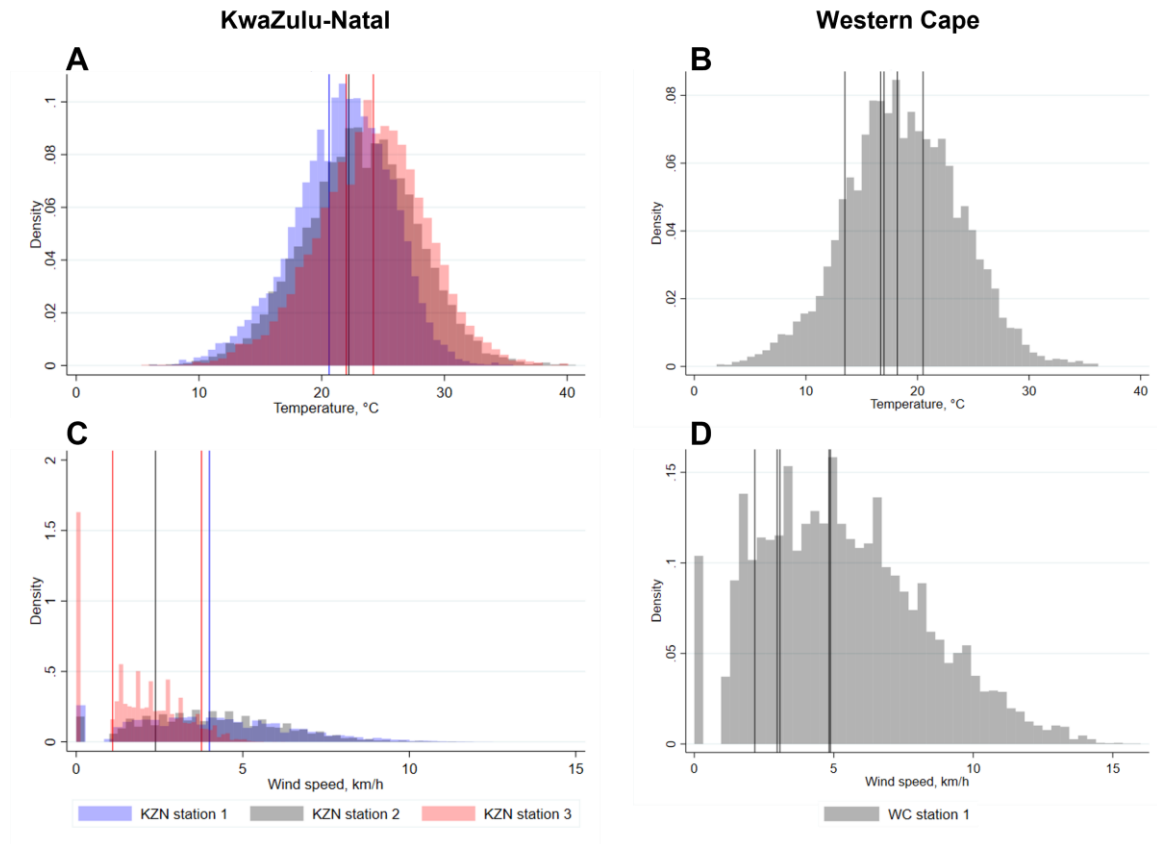


Fig C: The association between wind speed at the nearest weather station and the number of air changes per hour in 26 clinical spaces. Measurements were taken both under usual conditions (Beta: 1.56, 95% CI [-1.98 – 5.10]; R2: 0.03) and ideal conditions (Beta: 3.96, 95% CI [0.23 – 7.70]; R2: 0.17)

