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Re-evaluating March/April 2020 COVID-19 infections in dental staff – a novel application of a predictive computational model

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Additional Declarations: There is no duality of interest

Abstract

Introduction

A computational model developed by others was applied retrospectively to our survey data on dental staff to determine whether the pre-existing infection control practices left dental staff at greater risk of infection with Covid-19.

Method

Survey data was used and passed through a computational model. Methods were devised to check for impact of the missing variables in the survey data, compared to the dataset used for the development of the computational algorithm.

Results

The model predicted 82/2888 (2.84%) of dental staff were infected. The model correctly predicted the results of all seven respondents who also reported PCR test results. The lack of included data on sex in the original survey had no impact on the output of the model by itself.

Adding in the effect of skipped meals gave an upper bound of infected dental staff as 5.78%

Discussion

The model estimated between March 24th - April 21st 5.36% of mobile app users were infected with Covid-19. The estimated range of Covid-19 infections with dental staff compared favourably with this.

Conclusion

UK dental staff did not appear to be at increased risk of infection with Covid-19 compared with the background population during the beginning of the pandemic using the pre-existing infection control measures.

Introduction

To protect health-care workers (HCW) and patients from COVID-19 during the pandemic, UK authorities opted to take a precautionary approach. It was suggested dental-care professionals (DCP) were at increased risk of COVID-19 infection given their proximity to the respiratory systems of patients and the routine use of aerosol generating procedures (AGP). [(1)] [(2)]Proposed means of transmission included surface contact, fomites, large droplets, respiratory aerosols and dental bio-aerosols. [(1, 3, 4)] In the absence of directly applicable evidence, dental COVID-19 risk assessments were formulated utilising aerosol science and a hierarchy of hazard risk controls. [(5-7)] From 25 March onwards dental teams ceased face-to-face consultations and treatments.

The first SARS-CoV-2 case in the UK was confirmed on 30th January 2020. [(8)]Case numbers and hospitalisations rose rapidly throughout February and March 2020. During this period it is likely that dental teams would have been exposed to increasing numbers of infected patients. Version 1.0 of the NHS Standard Operating Procedure (SOP) dated 27 February 2020 states, “A possible case of COVID-19 needs to meet both the clinical symptoms AND have a travel history, including travel to, or transit through (for any length of time), the identified risk countries OR contact with a confirmed case of coronavirus.” [(9)]Category 1 countries included Iran, Korea, Italy and parts of

China; and Category 2 involved areas of East and South East Asia. Dental patients infected via UK community transmission would not have met the definition in v1.0 of the SOP. Furthermore COVID-19 polymerase chain reaction (PCR) tests were limited to a small number of inpatients and hospital staff, and the majority of infected dental patients would not have taken such tests. Therefore it is probable that prior to 25 March 2020, many dental teams unknowingly provided care to SARS-CoV-2 positive patients.

It was widely believed that existing dental infection control procedures were insufficient to effectively mitigate SARS-CoV-2 transmission, putting dental teams at increased occupational risk. The expectation therefore would be an increase in the reporting of COVID-like symptoms amongst DCP during the early period of the pandemic. Accordingly this early phase provides a unique opportunity to observe the effectiveness of standard pre-pandemic infection control measures. In the absence of widespread PCR testing of dental teams, assessment of COVID-like symptoms reported by DCP during this early period would provide a surrogate endpoint. It was hoped that later analysis of this data could assist in developing risk assessments and mitigation strategies for future respiratory pandemics.

Predictive Computational Modelling

From the start of the pandemic the UK has conducted continuous population-wide surveys to estimate disease prevalence, geographic spread and monitor COVID-19 symptoms. The largest of these surveys (a collaboration between King's College London, Massachusetts General Hospital and ZOE), utilised daily symptom reporting via a mobile app (COVID Symptom Study, ZOE Global Limited). [(10)] Between 24 March and 21 April 2020, 2,618,862 users in the UK and the USA reported on their symptoms. [(11)]It was understood that the characteristic symptoms of COVID-19, a persistent cough and/or fever, can resemble those of other respiratory diseases, e.g. common cold or influenza. Of the respondents reporting COVID-like symptoms, 18,401 also reported the results of their PCR tests. The application of logistic regression to the data (including the results of the PCR tests), allowed researchers to develop a computational model identifying probable COVID positive individuals based solely on the reporting of COVID-like symptoms. [(11)](**see Figure 1**) The model continued to provide real-time monitoring of COVID-19 prevalence for more than two years.

This paper reports on the application of this predictive model to estimate COVID-19 infection in DCP prior to 17 April 2020, i.e. whilst working under standard pre-pandemic infection control measures.

Methods

The survey method has been previously described. [(12)]Data was collected between 10 April and 17 April 2020. The survey data was passed through the predictive model run on a spreadsheet (Microsoft Corporation, 2018. *Microsoft Excel*, Available at: https://office.microsoft.com/excel).

The original survey questionnaire did not record age, skipped meals or sex. Whilst at the time of the survey, age and sex were recognised predictors of disease severity; it was not known that skipped meals, age or sex were potential predictors for infection.

With a weighting coefficient of 0.01 the impact of age was deemed insignificant. However it was not known if the absence of data on skipped meals was potentially significant on the model's outcome. The original survey also did not record the sex of the respondents and the potential impact on the model's prediction was unknown. A suitable

work around was fashioned whereby the effects of these omissions could be evaluated. The model coded sex as a categorical variable: “male” had a nominal value of “1”, and “female” a nominal value of “0”. The same approach was followed with “skipped meals”. To evaluate the significance of not having any data on skipped meals and sex, the model was re-run under four postulates:

1. all subjects male and all reporting no skipped meals
2. all subjects female and all reporting no skipped meals
3. all subjects male and all reporting skipped meal
4. all subjects female and all reporting skipped meals

Results

Out of the 2888 survey responses, the model predicted 82 DCP were infected (2.84%). As described in the method section, this prediction does not account for ‘sex’ or ‘skipped meals’ because these variables were not collected.

Re-running the model under the four differing postulates, the output was:

1. all subjects male with no skipped meals – 82 DCP infected (2.84%)

2. all subjects female with no skipped meals – 82 DCP infected (2.84%)

3. all subjects male and all reporting skipped meal – 167 DCP infected (5.78%)

4. all subjects female and all reporting skipped meals – 82 DCP infected (2.84%)

Internal validation of predictive model

Seven of the survey respondents also reported their PCR test results (3 positive, 4 negative). The PCR results of the seven respondents was compared with the predictions made by the model. The predictive model correctly identified the PCR results of these seven respondents.

Effect of missing sex data

As noted in the method, the model was sequenced twice to determine the impact of the respondent’s sex on the result. It was found that whether all of the respondents were nominally coded as female or male did not influence the model’s prediction: the percentage of survey respondents identified by the model as infected remained identical under either operational assumptions. The respondents who comprised the 2.84% ‘infected DCP’ were also identical regardless of sex.

Effect of missing skipped meals data

The predictive model uses self-reported COVID-like symptoms to provide a weighting coefficient to each of the symptoms. The mobile app was released on 24 March 2020 shortly before the survey, and the collection of survey data occurred prior to publication of the predictive model. Accordingly not all the symptom predictors are matched. The predictive model includes ‘skipped meals’. Unfortunately the survey did not enquire as to skipped meals and this predictor could not be directly included. The effect of this omission on the models predictions is unknown. However running the model with this predictor set as present in all those who self-isolated due to COVID-like symptoms, produced an outcome of 2.84% where the sex variable was set as ‘female’, and 5.78% where

the sex variable was set as ‘male’. Since it is improbable that all survey respondents were male, 5.78% represents the maximum possible number of infected DCP predicted by the model. When compared with the known results of the seven PCR tests, the predictions made by the model under this assumption remained internally valid.

Discussion

Predictive model analysis of the self-reported COVID-like symptoms would suggest 2.84%, (95% CI 2.24%, 3.44%] of UK Dental Professionals working under standard pre-pandemic infection control measures became infected before 17 April 2020. On 31 December 2019 113,439 Dental Professionals were registered with the General Dental Council. As previously noted the 2,888 survey respondents are not representative of all UK Dental Professionals. (11)Dental hygienists, dental therapists and dentists are overly represented in the survey. Since these registrants are those working in the closest proximity to patients’ respiratory systems and mouths, it is likely that the pre-pandemic PPE would have faced greater challenges in these members of the dental team.

The predictive model estimated that between 24 March and 21 April 2020 5.36% of mobile app users were infected with COVID-19. (11)Although the time period under current investigation commenced earlier – 10 February 2020 to 17 April 2020, the number of COVID-19 cases would have been small in February 2020. The predictive model suggests that DCP COVID-19 infection levels were lower than those in the community. Furthermore, during a similar time period (24 March – 23 April 2020), the same predictive model found UK front-line healthcare workers were at significantly increased risk of COVID-19 infection when compared with the general public. [(13)]Demographically black, Asian, and minority ethnic health-care workers were most at risk. Increased risk was also associated with PPE shortages and PPE reuse. Unfortunately the original survey did not record any demographics nor the availability of PPE, and neither of these relationships can be established from computational analysis the survey data.

It is likely there was a gradual reduction in patients attending routine dental appointments during February and March 2020. Such a situation would reduce DCP exposure to infected patients. However it would be expected that staff-to-staff work place transmissions should have remained similar to community background rates. This expectation was not observed. It may be existing pre-pandemic infection controlled procedures were influencing within workplace transmission and mitigating the spread of COVID-19 between members of the dental team.

Conclusion

This paper demonstrates the retrospective application of a predictive computational model unavailable at the time of collection of survey data. At the time of the survey it was hoped that the data could later be analysed by others to determine the actual risks faced by the dental team using pre-pandemic infection control protocols. This information could then be used to develop evidence based risk assessments and mitigation strategies for future respiratory pandemics.

According to this computational modelling of COVID- like symptoms in UK DCP, SARS-CoV-2 infections remained lower than those in the community. Contrasting data from other front-line HCW during the early phase of the pandemic, DCP did not appear to be at increased risk of COVID-19 infection using standard pre-pandemic infection control measures. These observations merit deliberation during any ‘look-back’ exercise, since retrospectively they fail to support dental COVID-19 risk assessments or the implementation of enhanced infection control measures.

Declarations

Ethics declaration

Ethics approval was not required for this paper. The paper does not contain any data or methodology that has not already been published, nor does it involve any participants directly, and there is no potential for harm from the mathematical processing of data. The original data set together with method was published in: "COVID-19 self-isolation patterns in UK dental care professionals from February to April 2020" BDJ Vol 234 No.7 April 14 2023. There is a statement at the foot of the paper from the BDJ Editor-In-Chief regarding the ethics position. Prior to data collection, an assessment was made of the need for ethical review. The Heath Research Authority (HRA) online decision tool was used. The online HRA tool stated that we did not require ethics approval. A further step that we took to establish whether ethics approval would be needed or not was to look at the UK HRA 'Standard operating procedures for Research Ethics Committees', which clearly stated that research involving staff recruited by virtue of their professional role does not require REC approval (with certain caveats). All our subjects were DCPs (a valid GDC number was required to check this) and consent to participate was implied by completion of the survey, as we described in the first paper.

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Figures

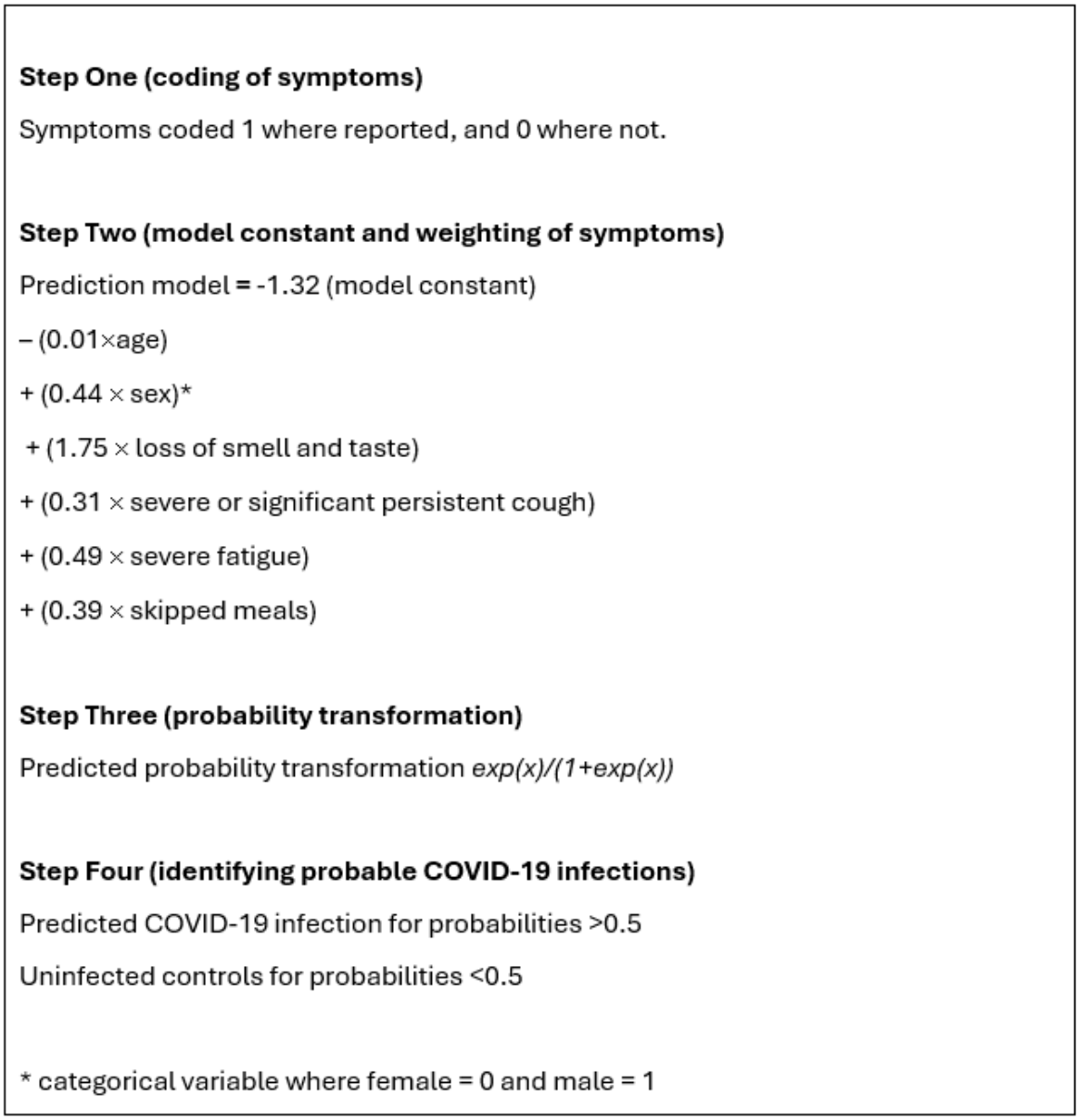


Figure 1

ZOE model for predicting probability of COVID-19 infection from self-reported symptoms [11]