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THE ECONOMIC IMPACT OF FALSE POSITIVITY OF COVID-19 PCR TESTING IN THE CZECH REPUBLIC

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Abstract:

The COVID-19 pandemic has affected the entire world, causing significant losses to the world's population's health, lives, and economic levels. The process of testing using RT-PCR tests also had other serious economic impacts. The testing process also sometimes results in erroneous results. One of them is false positivity. This article uses the Bayesian approach which estimates the economic impacts of false-positive results. The Bayesian approach takes into account a prior probability distribution depending on the prevalence of the disease in the population. False-positive results can be minimized by retesting positive persons who have no clinical symptoms of COVID-19. The costs of retesting these people are significantly lower than those associated with isolating them and quarantining their contacts.

Keywords:

Bayesian statistics, Macroeconomics, COVID-19, RT-PCR, False-positivity

JEL Classification: C11, C19, I10

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INTRODUCTION

The essential instrument how to monitor the spread of Covid is testing. Thousands of persons are tested every day because they have symptoms of the illness, have had contact with a positive person, or are tested preventively. A minority of them have a positive test result, and then they have to stay in quarantine, start tracing their contacts, etc.

In the testing theory, there are two possible mistakes in the test. The first one is false negatives – giving a negative result for a person infected with COVID-19. The second one is false positives – giving a positive result for a person not infected with COVID-19 (Mayers and Baker, 2020). False negatives must be reduced because of the epidemiological point of view. On the other hand, reduction of the false negatives increases false positives. At first glance, false positive is not "dangerous", but it could cause many problems such as delaying surgeries, unnecessary quarantine and treatments, transplant lists omission, and unnecessary sick leaves (Alsheikh, Ibrahim and AlFaraj, 2021). But mentioned problems are mostly related to health care (or only). There could also be some economic impacts as persons in quarantine cannot attend work and must reduce their consumption.

This article aims to estimate the economic impact of false positivity in summer. The summer values of newly detected positive cases ranged in hundreds per day. However, the number of tests was higher than in previous periods and, on some days, reached the limit of 50 thousand PCR tests, similar to the level of solid waves in autumn or spring. From this, it can be concluded that the viral load in the population, and the associated number of patients (prevalence), was very close to zero during the summer period (Mazouch, Fischer and Karel, 2022).

1 LITERATURE OVERVIEW

There is a minimal number of articles related to false-positive of Covid testing. In June 2020, Carl Mayers and Kate Baker published the article "Impact of false-positives and false-negatives in the UK's COVID-19 RT-PCR testing program". They discussed the causes of false positives, estimated the introductory false-positive rate for the UK, and discussed why false positives are a problem with the conclusion that a proportion of infections we currently view as asymptomatic may be due to these false positives. It raises the risk of overestimating the COVID-19 incidence, the demand on track and trace, and the extent of asymptomatic infection (Mayers and Baker, 2020).

Basile et al. (2020) published an article discussing the consequence of false positivity in Australia. They mentioned concrete situations where especially asymptomatic individuals with no identified epidemiological links is an approach that laboratories have implemented to reduce the risk of false positivity. The problems as that "unrecognized false-positive results can lead to unnecessary quarantining and contact tracing, delays in the recognition and treatment of the true illness, significant patient anxiety and concern, potential exposure to nosocomial infection from other patients with confirmed COVID-19, wastage of personal protective equipment, and inaccurate statistics regarding the local prevalence of infection" (Basile at al., 2020) were mentioned.

Also, a paper published by Alsheikh, Ibrahim and AlFaraj (2021) mentions very similar results of the false positivity as previously mentioned articles with concrete examples of postponed therapy. Specifically, they mentioned "delaying surgeries, transferring the patients to COVID-19 isolation wards, unnecessary quarantine and treatments, transplant lists omission, and unnecessary sick leaves. Therefore, more attention should be directed toward this issue, and a thorough evaluation of the suspicious cases should be performed" (Alsheikh, Ibrahim and AlFaraj, 2021). Another article by Healy et al. (2021) brings the same conclusions.

All mentioned articles focus on the health-related impact of false positivity. Surkova, Nikolayevskyy and Drobniewski (2020) split the impact from an individual and global perspective. Besides the health-related impact, they also mentioned psychological and financial aspects. In the financial area, they put stress on financial losses related to self-isolation, income losses, canceled travel from an individual perspective and misspent funding (often originating from taxpayers) and human resources for test and trace, unnecessary testing, funding replacements in the workplace and various business losses (Surkova, Nikolayevskyy and Drobniewski, 2020).

There are no deeper analyses of false positivity published yet in the Czech Republic. There are demographical analyses of the impact of Covid-19, for example, article by Hulikova Tesarkova and Dzurova (2021) or Klimkovsky, Nemec and Bouckaert (2021) proving that the Czech Republic was one of the most affected countries. Economic aspects of pandemia were analyzed by Nemec and Spacek (2020) and with a particular accent on the government's behavior in the contribution of Kaderabkova and Jasova (2021).

2 INTRODUCTION TO BAYESIAN STATISTICS

False positivity in testing is connected to the conditional probability paradox and Bayesian statistics. The history of Bayesian statistics dates back to "An essay towards solving a problem in the doctrine of chances", written by the Presbyterian minister Thomas Bayes in 1763. This work was not published until after Bayes' death by his friend and colleague Richard Price. Reverend Price was also a Presbyterian minister interested in philosophy, mathematics, and logic. An essay towards solving a problem in the doctrine of chances (Bayes, 1743) aroused wide controversy in the circles of mathematicians of the time. Bayesian inference is based on combining a priori knowledge (external information - Prior) and a function of the parameters of a statistical model given data (Likelihood) derived from the data (Bolstad, 2007).

$$POSTERIOR \propto PRIOR \times LIKELIHOOD \quad (1)$$

The basic form of the Bayesian formula shows the relationship between conditional probabilities

$$P(B|A) = \frac{P(A|B) \times P(B)}{P(A)}, \quad (2)$$

where $P(B|A)$ represents the posterior probability, $P(A|B)$ represents likelihood from data and $P(B)$ is a prior distribution. Then $P(A)$ represents the total probability formula. The formula of a total probability can then be written down as

$$P(A) = P(A|B) \times P(B) + P(A|\bar{B}) \times P(\bar{B}) \quad (3)$$

The Bayesian formula in case of medical testing could be written down as

$$P\left(INFECTED \middle| POSITIVE\right) = \frac{P\left(POSITIVE \middle| INFECTED\right) \times P\left(INFECTED\right)}{P\left(POSITIVE\right)} \tag{4}$$

where

$$P\left(POSITIVE\right) = P\left(POSITIVE \middle| INFECTED\right) \times P\left(INFECTED\right) + \\ + P\left(POSITIVE \middle| NONINFECTED\right) \times P\left(NONINFECTED\right) \tag{5}$$

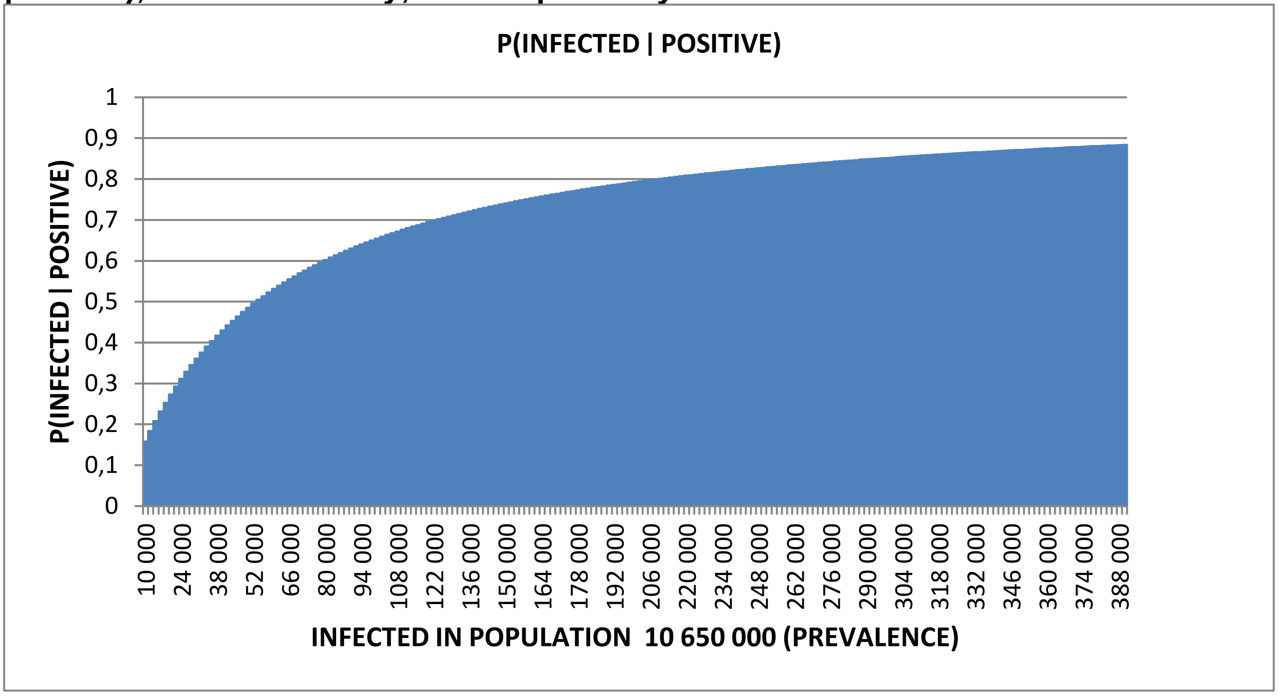
If we are interested in the number of really positive cases, i.e. the probability that the person who was tested positively is infected $P(INFECTED|POSITIVE)$, we must take into account the prevalence of the disease in the population $P(INFECTED)$. This prevalence of the disease has a significant role in the population and represents an a priori distribution in terms of the Bayesian statistics.

However, the group of so-called false positive (FP) persons is also hidden in the group of positively tested persons. Test manufacturers report specificity of the tests (the ability of the test to identify a noninfected person greater than 95% correctly), which may seem at first glance that the proportion of false positives among all tested should be very low (and approximately stable over time). However, in the case of a low prevalence period $P(INFECTED)$, such as in summer in the Czech Republic, the proportion of false positives can be very high among all positive tests (even most positives can be false positives).

3 APPLICATION OF BAYESIAN STATISTICS

This situation could be illustrated in a hypothetical example, where a PCR test would always be able to detect a truly infected person (sensitivity is 100%) and, in 99.5% of cases, correctly identify a healthy individual (99.5% specificity). In the Czech Republic, 10,000 would be infected with the SARS-CoV-2 virus at some point. Therefore, a randomly chosen person without any clinical symptoms would be sent for a PCR test, which would then turn out to be positive. However, it may seem common sense at first glance. Even if this method correctly detects a healthy person in 99.5% of cases, the actual posterior probability that a person is infected by a virus when a test is positive is 15.8%. In a period of relatively low prevalence (and low viral load in the population), the influence of the so-called conditional probability comes into play, which is dealt with in the approach called Bayesian statistics. The key to understanding this problem is that if the test correctly identifies all 10,000 infected (100% sensitivity) and 99.5% of all healthy, there are 0.5% of healthy people left who are incorrectly identified as positive. In the population of 10,650,000 inhabitants, there are 10,650 of these false positives. In total, 20,650 people are marked as positive (all positive and false positive), and only 15.8% (10,000 out of 63 291 people with positive test results) are indeed infected.

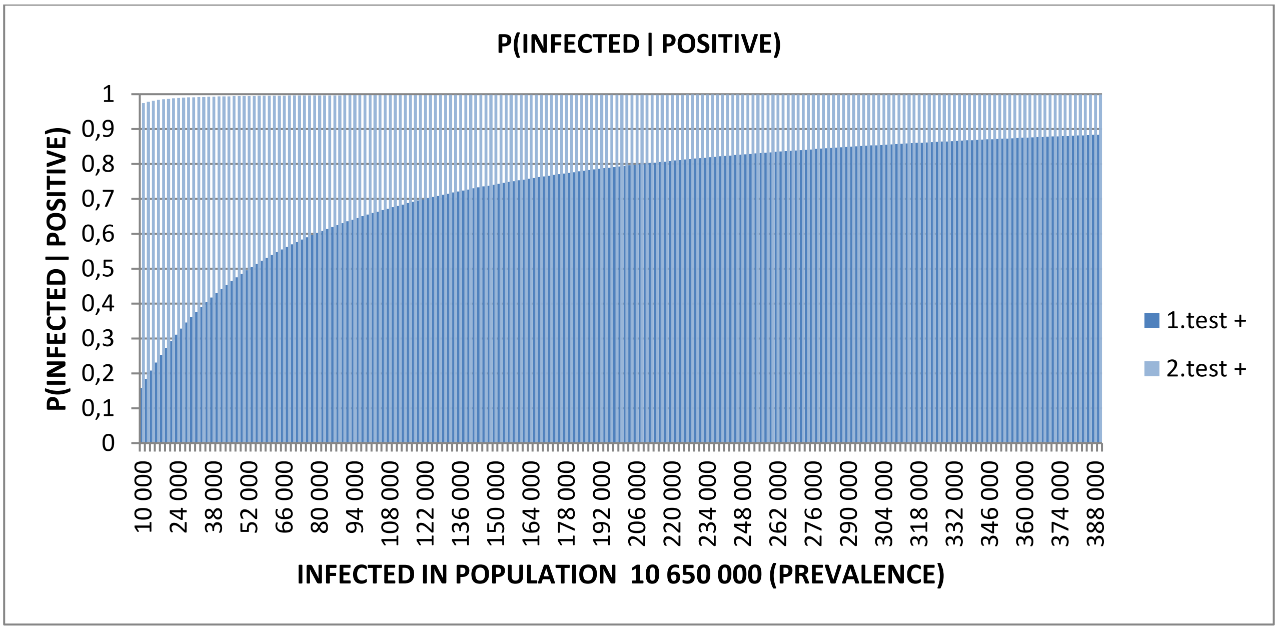
Figure 1: The posterior probability (a person is infected given that the first test was positive), 100% sensitivity, 99.5% specificity



Source: own calculations

But if a person is retested by the RT-PCR test, and gets a positive result again, the chances that a person is indeed infected with the virus would now be more than 97.4%.

Figure 2: The posterior probability (a person is infected given that the first and the second test were positive), 100% sensitivity, 99.5% specificity



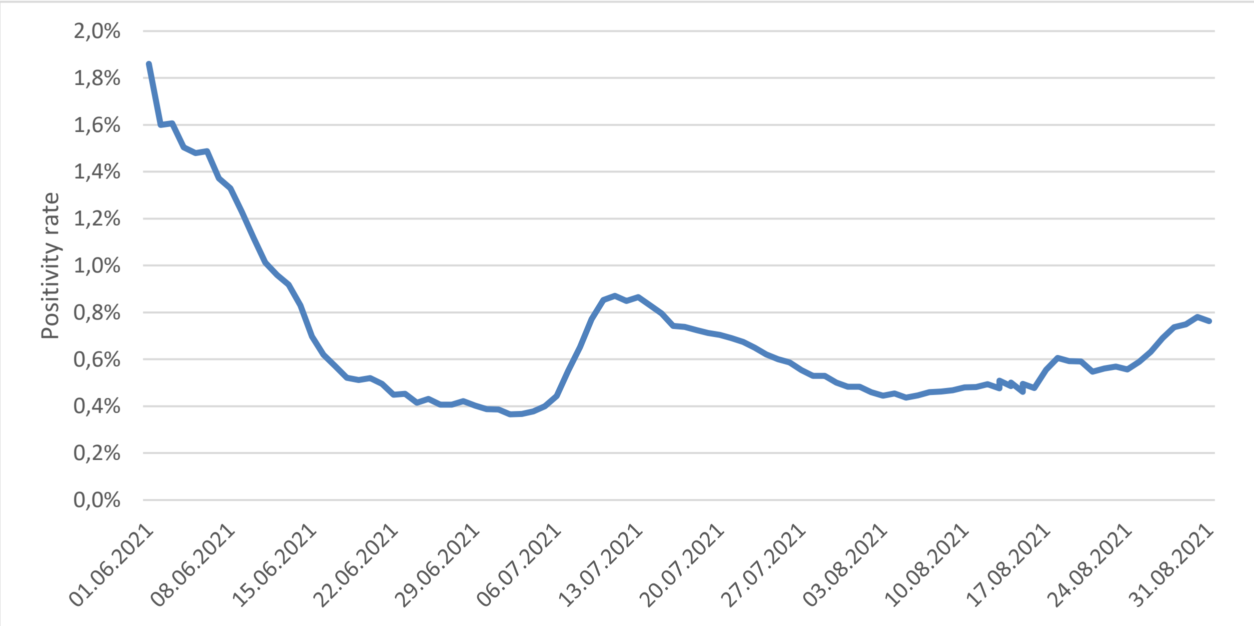
Source: own calculations

It should be noted that the actual values of the test specificity (probability of false positivity) are not only decided by studies performed in an isolated laboratory environment. The true value of the test specificity is thus linked to the whole testing process. In this process, it is possible to make a mistake and contaminate the sample already during the collection, subsequently during the testing process in a laboratory, by an error during the evaluation, or administrative error in sending the result. The stated upper limits of the specificity of the tests will therefore differ from the actual ones and will be lower.

4 DATA AND VARIABLES

From the beginning of June to the end of August 2021, the share of positive tests reached the minimum value at the beginning of July, when the seven-day average fell to 0.37% (Ministry of Health, 2022b). Unfortunately, the exact level of false positivity cannot be estimated from the available data. Still, it can be assumed that its values will be close to the minimum overall positivity level. Therefore, other calculations are not performed for one value but modeled variants for different levels.

FIGURE 3: Positivity rate (seven-day moving average), Czech Republic, 1.6.-31.8.2021



Source: Ministry of Health, 2022

In the summer of 2021, the system in the Czech Republic was set up in such a way that, with a positive PCR test result, the individual was ordered to be isolated for 14 days, and the individual was thus excluded from social and professional life for this period.

According to the rules in force in the summer of 2021, the ordered 14-day isolation did not only affect directly tested individuals but also all those who met such a person (Public Health Office, 2022). According to statistics, one positive person reported an average of 1.5 other persons (Chytra Karantena, 2022), who also have to be quarantined for 14 days (if they were not tested during the positive, then they go into isolation). Persons who have completed vaccinations and a predetermined period have elapsed since the last dose did not have to quarantine (Covid Portal, 2022c). There were about 50% of such people in the summer (Ministry of Health, 2022c).

Let's consider that an economically active person in isolation/quarantine takes an average gross wage of CZK 35,000 and the share of economically active in isolation/quarantine is 60%. It is possible to calculate the direct impact of unpaid wages of these persons on premiums and income tax.

There are further losses for employers here because they are obliged to pay their employees compensation for the first 14 days, which in the case of a gross salary of CZK 35,000 is approximately CZK 9,600 (Covid Portal, 2022b). In addition, if the employer were forced to replace the isolated / quarantined employee with another full-fledged employee, he would have to pay them an adequate wage (but there would be no loss of income from premiums and income tax in the case of budget revenues).

5 RESULTS

From the results in Tab. 1, it can be seen that with a very conservative variant of the false positivity rate at the level of 0.1%, the economic loss for the period from Jun 1 is at the level of approximately CZK 52 million, at the level of 0.3% the loss is already 156 million and at 0.5% % 260 million. For employers, the loss is significantly higher (when the wage compensation for quarantine/isolation and the compensation of the substitute employee). With a false positivity value of 0.1%, it is approximately 170 million, with a level of 0.3% already more than 500 million and with a value of 0.5%, it is almost 838 million crowns.

Table 1: Estimation of false-positivity – different scenarios (general positivity rate 0.6 % and 2 500 000 realized tests*)

False positivity rate	0.1 %	0.3 %	0.5 %
Number of positive tests	17 000		
Number of false-positive persons	2 830	8 490	14 150
Number of persons in quarantine or isolation due to false positivity	4 953	14 858	24 763
Economically active in this group	2 972	8 915	14 858
Economic loss from social contribution and income tax	52 001 250	156 003 750	260 006 250
Employers' contribution to quarantine/isolation of false-positive persons	28 526 400	85 579 200	142 632 000

Wages paid to replaced employees	139 363 350	418 090 050	696 816 750

*Number of tests between Jun 1 2021, and Aug 31 2021

Source: own calculations

6 DISCUSSING CONCLUSIONS

The essential prerequisite for eliminating economic and epidemiological damage is improving the accuracy of testing results and suppressing false-positive results. Such measures include, for example, improving (or rather better extraction because data are already being collected) data on the person being tested: e.g., information on whether they have symptoms of the disease or whether they have recently been in contact with an infected person. Suppose such information leads to the finding that the probability of infection was low. In that case, the easiest way is to repeat the test because the first test result is probably a false positive.

In the borderline case, if we repeated all the positive tests, the additional costs from the beginning of June to the end of August will amount to approximately CZK 11 million (the price for one RT-PCR test is around 614 CZK – Ministry of Health, 2022d). It means approximately 1/5 of the loss on social security and health insurance contributions and personal income tax. That was a false positive (in the model with the lowest false positive rate). Compared to the impact on the economy, this amount and employers, but especially on individuals who, due to false positives, had to cancel family holidays, for example, is entirely negligible.

When repeating the test, the time between the first positive result and the result of the repeated test must also be taken into account. During it, it is necessary to look at the person as positive. During the holidays, the standard time for publishing the result was 48 hours, but most laboratories reported within 24 hours (Covid Portal, 2022a). Thus, a false positive individual would be limited disproportionately shorter. Also, any contacts handed over to the Regional Hygiene Station would either not be contacted at all during this time or be possible to correct the information after receiving a repeated (negative) result. In any case, there would be significantly smaller losses than in the standard procedure.

If we still focus on the possibility of retesting in a period other than summer, in which we illustrated the effects of false positivity, we can look at November 2021. This month, more than 2 million PCR tests were performed (Ministry of Health, 2022a), of which almost 375,000 people were positive (the positivity rate was almost 19%). However, 165,000 people were positive and had no symptoms (so-called asymptotic). Of course, the viral load was significantly higher in the population than in the summer, so not all asymptomatic people can be considered a false positive. However, if we applied the principle of repeating the test to these people, the increase in the number of tests performed would be about 8%. In this case, the question is whether this number would no longer significantly increase the total cost of testing (costs would increase by more than CZK 100 million in November 2021 alone) and whether the system would withstand this increased burden.

The complete analysis should be used to assess whether the parameters of the current system are appropriate in different periods and whether it is not necessary to open the question of retesting.

One way could be voluntary retesting not covered by public funds. In critical periods (such as November and December 2021), this would not necessarily mean that the ordered isolation (or, in the case of quarantine contact) will be lifted immediately due to limited testing capacity. Still, it would certainly help address the epidemiological problem of false infectivity. False-positive persons would not be issued a certificate of infectivity valid for 180 days, as is currently the case, because the risk associated with false positives is not only in the economic field. Isolation is ordered from a false positive person, and upon termination, they will receive a certificate of illness. The validity of such a certificate is 180 days.

If the low level of false positivity of 0.1% again applied, approximately 2,800 people would have this certificate "unjustifiably" available (from Jun 1 2021, to Aug 31 2021). However, if the false positivity were higher, at the level of 0.3%, there would already be 8,500 of them. At 0.5%, it is even 14,150 persons (the total number of positive persons was 17.5 thousand in the analyzed period). There is also the issue of possible re-infection with this number. If any of these people are truly positive in the next period, they will be considered re-infected, affecting various measures or conclusions about the virus's behavior.

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