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Assessment of a SARS-CoV-2 population-wide rapid antigen testing in Italy: a modeling and economic analysis study

Marianna Cavazza [1], Marco Sartirana[1], Yuxi Wang [2], Markus Falk[3]

1 Cergas (Centre for Research on Health and Social Care Management) - SDA Bocconi School of Management, Bocconi University, Milano, Italy
2 Dondena Centre for Research on Social Dynamics and Public Policy, Bocconi University, Milano, Italy
3 EURAC Research, Bolzano, Autonome Provinz Bozen—Südtirol, Italy

Correspondence: Marianna Cavazza, Cergas (Centre for Research on Health and Social Care Management) - SDA Bocconi School of Management, Bocconi University, Via Sarfatti 10, 20136 Milano, Italy, Tel: +39 (0)2 58362664, e-mail: marianna.cavazza@unibocconi.it

Background: This study aimed to compare the cost-effectiveness of coronavirus disease 2019 (COVID-19) mass testing, carried out in November 2020 in the Italian Bolzano/Südtirol province, to scenarios without mass testing in terms of hospitalizations averted and quality-adjusted life-year (QALYs) saved. **Methods:** We applied branching processes to estimate the effective reproduction number (Rt) and model scenarios with and without mass testing, assuming Rt = 0.9 and Rt = 0.95. We applied a bottom-up approach to estimate the costs of mass testing, with a mixture of bottom-up and top-down methodologies to estimate hospitalizations averted and incremental costs in case of non-intervention. Lastly, we estimated the incremental cost-effectiveness ratio (ICER), denoted by screening and related social costs, and hospitalization costs averted per outcome derived, hospitalizations averted and QALYs saved. **Results:** The ICERs per QALY were €24 249 under Rt = 0.9 and €4604 under Rt = 0.95, considering the official and estimated data on disease spread. The cost-effectiveness acceptability curves show that for the Rt = 0.9 scenario, at the maximum threshold willingness to pay the value of €40 000, mass testing has an 80% probability of being cost-effective compared to no mass testing. Under the worst scenario (Rt = 0.95), at the willingness to pay threshold, mass testing has an almost 100% probability of being cost-effective. **Conclusions:** We provide evidence on the cost-effectiveness and potential impact of mass COVID-19 testing on a local healthcare system and community. Although the intervention is shown to be cost-effective, we believe the initiative should be carried out when there is initial rapid local disease transmission with a high Rt, as shown in our model.

Introduction

Literature and research question

During the first and the second waves of the coronavirus disease 2019 (COVID-19) pandemic in 2020, before vaccines became widely available, policymakers' main goal was to identify the most effective and feasible strategy for breaking the chain of infections. One possible solution was population-wide testing (or mass testing) using antigen tests.

In 2020, the European Centre for Disease Prevention and Control (ECDC) first published guidelines[1] and then collected early evidence from Member State and UK experiences, outlining the advantages and disadvantages of this type of intervention and identifying conditions under which it should be required.[2] Specifically, ECDC suggested that the relevant costs of the intervention can be offset by decreased pressure on healthcare systems, reduced work absenteeism and the loosening of stringent measures preventing normal social life.

Subsequent literature has provided new evidence by (i) carrying out simulations of various interventions and estimating possible outcomes[3,4] even considering the very same experience of province of Bolzano/Südtirol,[5] (ii) providing evidence from worldwide experience,[6,7] (iii) focusing on its cost-effectiveness with respect to alternative strategies or sets of alternative strategies,[8,9] (iv) assessing the length of any associated positive impact[6] and (v) estimating how many positive cases are on average detected through mass testing of asymptomatic and/or high-risk populations.[10–13]

However, most of this scholarship refers to a relatively limited population in high-risk settings (e.g. highly densely populated areas, healthcare workers).[1,2,13] Several studies provide evidence from mass testing whose target includes the asymptomatic population living in a geographical area (e.g. an Italian municipality, the northern metropolitan area of Barcelona, the entire population of Slovakia).[11,12,14] Yet, except for the cost–benefit analysis carried out by Lòpez Seguì et al. in Barcelona,[12] and the cost-effective analysis of a pilot test in a Welsh Borough by Drakesmith et al.,[9] these papers describe the main outcomes achieved in terms of the asymptomatic population tested, false-negative test rates, COVID prevalence variation and avoided deaths, and inpatient stays through epidemiologic, compartmental, or observational models. Instead, cost-effectiveness analyses are provided only through theoretical simulation models, for instance, by Ruddy et al. in the South African context[15] and by Paltiel et al.[3] among college campus populations in the USA in 2020, and one year later for the whole US population.[16]

Hence, the mass testing carried out in the Italian province of Bolzano/Südtirol, in November 2020, represents an excellent case study using real-world data to apply not only a compartmental model but also a cost-effectiveness analysis of mass testing with respect to no intervention. Specifically, providing evidence regarding the effectiveness and potential impact on the local healthcare system and community, we address the following research questions: (i) What would have happened in terms of infection spread if the province of Bolzano/Südtirol had not organized the mass testing in terms of infection spread? (ii) In a context where vaccines were not yet available and the contact tracing of symptomatic citizens was largely failing because of a rapid outbreak, was the mass testing of asymptomatic citizens a cost-effective initiative compared to doing nothing (i.e. the only available option at that very specific moment).

Methods

Study design and setting

The Italian healthcare system is a regionally based, national health service that provides universal coverage largely free of charge.[17] Local Health Authorities (LHAs) are responsible for public health, primary, secondary and tertiary care.[18] The LHA of the Bolzano/Südtirol province, a territory with 530 000 inhabitants, directly operates seven hospitals and commissions services from a handful of private accredited providers, mostly providing long-term care.

During the first wave of the COVID-19 pandemic, a strict national lockdown ensured that contagions and deaths (over 35 000) were largely concentrated in a limited number of areas. The second wave of the pandemic (October 2020 to January 2021) affected the entire country, with eight times the number of contagions, over 60 000 deaths, and considerable pressure on the availability of hospital and intensive care unit (ICU) beds. In November 2020, a curfew and lockdown for various regions—including the Bolzano/Südtirol province—were introduced, with closures of schools, shops, and restaurants and orders to stay at home.

Specifically, in October 2020, as COVID-19 cases continued to surge, the LHA took decisive action by implementing a curfew on 24 October. The contact tracing efforts were overwhelmed by the substantial workload, severely impeding their ability to effectively track and trace potential COVID-19 cases. Furthermore, despite the initial closure of schools during the fall holidays in week 45 (November 2–8), the number of hospitalized cases nearly doubled during this period, leading to the implementation of a general lockdown. This lockdown necessitated the closure of shops and restaurants while workplaces remained operational. Although hospital occupancy eventually stabilized after 1 week, the decline was gradual. With the goal of significantly reducing hospital occupancy within a short timeframe, a mass testing campaign was proposed, aiming to disrupt infection chains. Looking at the recent experience in Slovakia and similar initiatives underway in neighboring Austria, policymakers perceived the mass testing as the only available solution to stop the infectious chain.

It was estimated that reaching a participation rate of 70% would have brought the effective reproduction number (Rt) levels down from 0.8 to 0.5.[19] Specifically, an evaluation of the mass testing's possible impact was carried out by an independent local research centre (EURAC research) using a branching process epidemic model with a negative-binomial offspring distribution[20,21] (see supplementary material). Moreover, the Bolzano/Südtirol province collected and processed the data used in this study, which is provided once it had been anonymized and widely aggregated. Furthermore, the SARS-CoV-2 data, publicly available, are provided by the Disaster Relief Agency (Protezione Civile).

In mainly 3 days (November 20–22), following a massive communication campaign, a mass testing campaign using exclusively the STANDARD™ Q COVID-19 Ag Test (SD Biosensor, INC, Republic of Korea) and involving 1937 health professionals and aid workers was conducted in public places such as schools, city council offices, etc. Moreover, in the following 5 days, pharmacies provided a few thousand more tests. Out of the total 361 781 tests administered, there were 3615 positive cases identified, representing a positivity rate of 1.0%. It is noteworthy that the campaign achieved a participation rate of 71.9% among individuals aged 6 years and above and 65.2% out of the whole population. Based on an assumed sensitivity of 70% and a specificity of 99.9%, along with the fact that 40% of cases were asymptomatic, the estimated true prevalence was found to be 3.2%. This indicates that there were approximately 11 600 prevalent cases at the time of testing.

Individuals who tested positive (at that time, a figure lower than expected) were asked to isolate for 10 days and contact their doctors in case of symptoms. A confirmatory polymerase chain reaction (PCR) test was provided upon request only to patients who declared no contacts with potentially positive cases. After 10 days, in the absence of symptoms, the isolation ended without a confirmatory test (see supplementary figure S1). Contact tracing was not performed, except in a highly limited number of cases, due to a lack of financial and human resources available, as in most Italian regions. The initiative was meant as a single mass testing, without follow-up, but a sample of 4000 randomly selected people was tested weekly over the following 4 weeks.

After the mass testing, the number of cases initially declined, and schools and commercial activities were gradually opened. However, soon the Rt index returned to the 0.8 value registered before the mass testing, and in the following weeks, the number of contagions was among the highest in the country. A new partial lockdown had to be introduced, and ski facilities remained closed. No other Italian regions or provinces repeated the mass testing experience.

Model description and assumptions

We used a branching process epidemic model with a negative-binomial offspring distribution[20–25] to estimate the Rt and model scenarios with and without mass testing, offering considerable advantages in contrast to SIR/SEIR models due to a lower number of model parameters.[26] Model parameters are partially derived from epidemic data already collected from the COVID epidemic up to the point policymakers took their decision, while critical parameters such as the Rt were estimated from data or set according to assumed values for modeling different infection scenarios (see the epidemiologic model description in the supplementary materials).

The model input data can be found in table 1. Specifically, an Rt of 0.88 was observed before mass testing started (i.e. on average, a new infection case gives rise to 0.88 additional cases under the mass testing scenario). The proportion of positive cases requiring hospitalization and ICU stays is based on earlier data, which are respectively about 7% and 0.6%. The proportion of deaths among ICU patients is estimated to be around 25%. It was estimated that those hospitalized would need on average 11 (non-ICU) bed days, while bed days for ICU patients were estimated on average at 14 days.

The observed scenario in the time lapse from 23 November to 31 December 2020 was compared with the simulated estimation to derive the number of detected infections averted, number of hospitalizations averted, number of ICU stays averted, and number of deaths averted under two transmission scenarios (Rt = 0.95 and 0.9) when there was no mass testing (see supplementary figure S2). We also derived the quality-adjusted life-year (QALY) and costs averted using the simulated outcomes and values derived from existing literature.

Cost analysis

We adopted different perspectives for estimating the costs of the intervention and the incremental cost in case of non-intervention, from 23 November to 31 December 2020. First, we estimated the mass testing costs by adopting a bottom-up approach, using valued cost components by directly identifying the resources employed.[31] We accessed detailed activity and input usage data from the LHA and all partner institutions to estimate the total costs of the intervention, even if not directly at the LHA expense. As far as staff is concerned, we had the direct costs (working time plus overtime) incurred by the LHA for the personnel involved, and with the total amount of hours employed by personnel of other institutions (Civil

Table 1 Model input parameters and assumptions

Model parameter	Input	Reference
Epidemiological Model		
Disease dynamics		
Mean serial interval following a gamma distribution with shape k = 2.88 and scale θ = 1.55	4.46	
Negative-binomial offspring distribution with dispersion parameter k	0.2	27
Effective Rt		
Base	0.88	Estimation
No testing good	0.9	Assumption
No testing bad	0.95	Assumption
Hospitalization and death		
% of detected case hospitalized (non-ICU)	7%	Estimation
% of detected case admitted to ICU	0.60%	Estimation
% of ICU patients deceased	25%	Estimation
Average bed days in general ward (non-ICU)	11	Estimation
Average bed days in ICU ward	14	Estimation
QALY		
Average QALY loss hospital bed day	0.0002	28
Average QALY loss for ICU bed day	0.0011	29
Average QALY loss for mortality	8.79882	30

Protection Agency, Red Cross, municipalities, fire brigades) which we multiplied by an average daily labor cost. We opted to not include only the cost incurred by volunteer personnel. We also estimated the direct costs of testing materials and consumables, as well as other costs associated with testing, such as disinfection services or garbage collection. Therefore, we estimated the communication and coordination costs, summing the daily labor cost of internal personnel directly employed in the initiative to the fees charged by external consultants. Finally, we also evaluated the societal burden of positive cases.

For the incremental cost estimates in the case of non-intervention, we did not refer to national average costs as we wished to capture site-level specificities in the care pathway of COVID patients and in the costs of inputs (especially staff, which in Bolzano/Südtirol is significantly higher than in other regional healthcare systems). Given the limited role of LHA primary care and outpatient facilities in assisting COVID patients, we only focused on hospitalization costs. We analyzed hospitalization in COVID general inpatient wards, COVID sub-intensive beds within general wards, COVID ICU wards and COVID long-term care wards. General wards with sub-intensive beds are present in all seven LHA hospitals, while ICU wards are present in five hospitals. Long-term care wards were provided only in some private accredited hospitals, reimbursed by the LHA.

We adopted a mixture of bottom-up and top-down methodologies,[32] based on the relevance of the different ingredients in the costing as well as data availability.[33] Concerning the daily cost of hospitalization, we used the values already calculated by the LHA in different departments through a mixed approach (developed by the Nisan network, see for instance Di Stasi et al.[34]), summing variable direct costs (staff, materials, consumables, etc.) with a percentage mark-up for overheads. For hospitalization in COVID general wards, we used the average daily costs in the internal medicine department in the main Bolzano hospital from 2019. For hospitalization in COVID sub-intensive beds—accounting for 20% of total beds in general wards, as emerged from semi-structured interviews with the physician in charge of COVID care—we used the average daily costs in the Bolzano infectious diseases department, calculated from 2019. For hospitalization in ICU COVID wards, we used the average daily costs calculated by the LHA from 2020 in the Bolzano COVID ICU department. We adopted a bottom-up approach in estimating the cost of hospitalization in COVID long-term care wards in private accredited hospitals, based on fixed daily reimbursement tariffs.

Table 2 reports evidence of the total costs of the mass testing intervention and unit costs of hospitalization.

Cost-effectiveness analysis

We primarily adopt a provider perspective and consider the direct medical costs as described above. The analysis compared the mass testing cost-effectiveness with scenarios without mass testing by estimating the incremental cost-effectiveness ratio (ICER), which is denoted by screening costs and hospitalization costs averted per outcome derived, hospitalizations averted and QALYs saved. While the rate of positive cases, hospitalization and death are estimated from our dataset (accessible online), the QALY values from these different health states are obtained from the literature.[28–30] We used a cost-utility model to assess the cost-effectiveness of mass testing considering the direct costs of testing and hospitalization.[32] In addition, we calculated the indirect costs taking into consideration the societal burden incurred due to working days lost determined by quarantine, hospitalization and recovery of patients. We subtracted the total number of working days actually lost due to the quarantine of patients who tested positive at the mass testing. The values are obtained from various sources including the Italian National Institute of Health (Istituto Superiore di Sanità), Bank of Italy, and the Bolzano province statistical institute. Due to the short duration of the intervention and observation period, we did not consider a discount rate. The willingness to pay per life year lost is a theoretical maximum price that a healthcare system is willing to pay to prevent the loss of one life year. Health economists have conducted studies to infer that in Italy the willingness to pay threshold is between €25 000 (minimum) and €40 000 (maximum).[35] We developed a probabilistic sensitivity analysis from the perspective of the healthcare provider to test how the cost-effectiveness of mass testing varies according to parameter changes. Using a total of 1000 Monte Carlo simulations, we vary the QALY (beta distribution) and cost (gamma distribution) parameters by ±25% for both alternative scenarios compared to the base scenario.

The epidemiological model and the calculation of ICERs were implemented in Microsoft Excel, while the sensitivity analysis was conducted using STATA 17.

Results

Estimates of epidemiological outcomes

The epidemiological model projected two alternative scenarios under Rt = 0.9 and Rt = 0.95. Three main epidemiological outcomes were considered: the number of detected cases, the number of hospitalized patients and the number of ICU patients. Supplementary figure S2 shows the trend of the outcome variables under the observed and the simulated scenarios. The number of cases detected under Rt = 0.9 and Rt = 0.95, although falling over time, remains mostly above the observed scenario of mass testing. This means that the mass testing seems to work well in averting the further spread of the virus given the high initial contagiousness. Regarding the hospitalization and ICU cases, the observed mass testing scenario has much lower cases than all the alternative scenarios when testing is absent. The differences are more pronounced for hospitalized and ICU cases. We obtain the cumulative differences as the cases/hospitalizations averted for the calculation of costs avoided and potential QALYs gained.

Costs

We have shown in table 2 that the overall mass testing cost is nearly €5.5 million. Using the unit costs of hospitalization from the second part of table 2 and the reference epidemiological model (see table 1), we derive the overall costs averted due to reduced infections from the mass testing. As seen in table 3, the overall healthcare costs saved through mass testing amount to around €4.652 million under Rt = 0.95 and around €2.851 million under Rt = 0.9. The

Table 2 Total costs of the intervention

Category	Items	Item units	Unit cost	Total cost
Staff	Physicians			€159.81
	Nurses			€1 222 793
	Administrative staff (municipalities)	281 days	€160.00	€451.36
	Administrative staff (CPA)	93 days	€160.00	€14.88
	Administrative staff (other)	411 days	€160.00	€65.76
	Total			€1 914 606
Testing materials	Test k	358.400		€2 444 288
	Kits			€6.00
	Other (gloves, face masks, protective gowns, etc.)			€782.02
	Total			€3 226 312
Other costs associated with testing				€174.65
Communication				€33.80
Coordination				€59.80
	Total			€5 409 166
Hospitalization				
	Hospital day in a general ward		€602.00	
	Hospital day in a sub-intensive bed in a general ward		€1123.00	
	Day in an ICU ward		€3243.00	
	Hospital day in a long-term care ward		€450.00	
Indirect costs				
	Average daily wage in private and public sectors		€136.70	
	Working days lost by positive cases not requiring hospitalization	10 days		
	Working days lost by hospitalized positive cases for recovery at home after hospitalization	11 days		
	% of working patients (equal to the % of positive cases aged 20–64)	64%		

Table 3 Costs avoided

	Daily hospitalization averted under Rt 0.95	Daily hospitalization averted under Rt 0.90	Daily costs	Direct costs avoided under Rt 0.95	Direct costs avoided under Rt 0.90	Indirect costs avoided under Rt 0.95	Indirect costs under Rt 0.90
Ordinary hospitalization	2941[a]	1783[a]	€602.00[b]	€1 770 323.00	€1 073 125.00		
Sub-acute	735[c]	446[c]	€1123.00[d]	€825.61	€500.47		
ICU	389[e]	246	€3243.00[f]	€1 261 750.00	€796.15		
Long-term care	1764[g]	1070	€450.00[h]	€794.00	€481.30		
Indirect societal costs						€3055.38	€468.09
Total	5829	3543		€4 651 683.00	€2 851 037.00	€4 651 683.00	€2 851 037.00

a: Difference between daily hospitalization observed by Alto Adige/Südtirol LHA and expected one.
b: Average daily cost observed in hospitals of Alto Adige/Südtirol LHA in 2019.
c: Observed rate of sub-acute daily hospitalization by Alto Adige/Südtirol LHA.
d: Average daily cost observed in hospitals of Alto Adige/Südtirol LHA in 2019.
e: Observed rate of ICU daily hospitalization by Alto Adige/Südtirol LHA.
f: Average daily cost observed in hospitals of Alto Adige/Südtirol LHA in 2020.
g: Observed rate of daily Long-Term Care hospitalization by Alto Adige/Südtirol LHA.
h: Daily fee of private accredited providers.

incremental costs are therefore the difference between the costs avoided and the cost of mass testing.

Cost-effectiveness analysis

Table 4 shows the results of the cost-effectiveness analysis. The ICERs per case averted were €154 under Rt = 0.9 and €1063 under Rt = 0.95, while the ICERs per QALY were €24 253 under Rt = 0.9 and €4623 under Rt = 0.95, considering the official and estimated data on disease spread. After incorporating the societal costs from work absence, the ICER values do not change significantly. The cost-effectiveness acceptability curves show the probability of being cost-effective on varying threshold values (see supplementary figure S3). We see that for the scenario when Rt = 0.9, at the maximum threshold value of €40 000 of willingness to pay, mass testing has an 80% probability of being cost-effective compared to no mass testing. Under the worst scenario when Rt = 0.95, at the willingness to pay threshold, mass testing has an almost 100% probability of being cost-effective (see supplementary figure S3). Lastly, the high fluctuation in supplementary figure S3 with negative peaks on Mondays is due to the fact that testing delivery was limited on Sundays (i.e. data were registered with a lag of 1 day).

Sensitivity analysis

The cost-effectiveness acceptability curves show the probability of being cost-effective on varying threshold values (see supplementary figure S4). We see that for the scenario when Rt = 0.9, at the

Table 4 Economic outcomes under alternative testing scenarios

	No testing with Rt 0.95 compared with mass testing, direct costs	No testing with Rt 0.9 compared with mass testing, direct costs	No testing with Rt 0.95 compared to mass testing, indirect costs	No testing with Rt 0.9 compared with mass testing, indirect costs
Costs				
Incremental costs	€757 483.41	€2 558 129.41	€754 428.03	€2 557 661.33
Incremental cost-effectiveness ratio				
ICER (EURO/infections averted)	154	1063	154	1062
ICER (EURO/hospitalization averted)	203	1148	202	1148
ICER (EURO/ICU averted)	1918	10 399	1910	10 397
ICER (EURO/death averted)	44 558	232 557	44 378	232 515
ICER (EURO/QALY)	4623	24 253	4604	24 249

maximum threshold value of €40 000 of willingness to pay, mass testing has an 80% probability of being cost-effective compared to no mass testing. Under the worst scenario when Rt = 0.95, at the willingness to pay threshold, mass testing has an almost 100% probability of being cost-effective (see supplementary figure S4).

Summarizing the results of our research questions, we show that the mass testing allowed for avoiding the provision of healthcare services and related costs as well as containing the social cost (see table 3), both under the best alternative scenario when Rt = 0.9 and when the infection rate is high at Rt = 0.95.

Discussion

Summarizing our key results, we see that even under the best alternative scenario when Rt = 0.9, the mass testing is cost-effective from a healthcare system point of view. Clearly, the intervention is even more cost-effective when the infection rate is high at Rt = 0.95. Therefore, Bolzano/Südtirol province experience shows that a mass testing targeting nearly a half million residents can be cost-effective even when it has a small impact in identifying the asymptomatic population living in a wide geographical area. In line with Mina et al.,[36] this experience informed a subsequent policy in the Bolzano/Südtirol province, which planned for mass testing in schools and groups of villages where infectious peaks occur. However, from the policymaker's perspective, the residents' large adherence highlighted the power of social capital in this territory,[37] and it led to increased resident awareness of local public institutions' commitment to addressing challenges associated with the pandemic, testing contributions from public (e.g. municipalities) and nonprofit stakeholders (e.g. Red Cross, voluntary fire brigades, etc.) in pandemic-related interventions, such as social aid to frail people during lockdowns and vaccination campaigns.

Our results are to be read and contextualized in a very specific but also common moment in a pandemic outbreak,[36] where the most effective and standard tools to break the infectious chain are not yet sufficient or available, and an eventual solution to handling the situation is identifying non-asymptomatic individuals as possible infection carriers using a less effective tool (i.e. antigen tests). A scientific debate about this approach arose around the time of the Bolzano/Südtirol province's decision to implement mass testing. For instance, a December 2020 *British Medical Journal* editorial[38] argued that the lack of strong evidence about the role played by asymptomatic cases in driving infection transmission and the poor detecting capacity of antigen tests should have stayed resource investment in asymptomatic detection. In the *New England Journal of Medicine*, Mina et al.[36] contended, however, that the use of antigen tests in mass testing could mitigate out-of-control pandemic outbreaks by identifying infection carriers despite a consistently lower detecting capacity. Moreover, this initiative was to be accompanied by frequent repetition in collective environments, with efforts to form an integrated pathway including both test types. Pugh et al.[39] recently summarized this debate's positions, concluding that the real issue to address is whether mass testing using antigen tests is cost-effective in containing a pandemic outbreak. Our analysis of the Bolzano/Südtirol province case provides evidence on this very aspect, grounded in real-world data and according to the decision-making constraints faced by policymakers. Ferrari et al. reached the same conclusion by applying a semi-parametric growth model in a synthetic control framework.[5] Further evidence is provided by the evidence-based experience of the Barcelona metropolitan area, where the rate of identified positive cases is similar and the cost–benefit analysis is positive only if a monetization of health is included in the benefits.[13] Likewise, the mass testing pilot run in the South Wales Borough of Merthyr Tydfl in late 2020[10] estimates a positive ICER, providing evidence about some relevant aspects untraceable in the Bolzano/Südtirol case, such as the effectiveness level of antigen tests with respect to a PCR test and the impact of positive individuals' viral load on the community through a contact tracing activity. These aspects were investigated to some extent in two previous papers which also provided evidence from areas close to Bolzano/SüdTirol (northeastern Italy), such as the small Vo' municipality[12] and healthcare workers at the Verona hospital.[14] They both provide evidence and insights about asymptomatic infection and the transmission dynamics on one side and the effectiveness of a surveillance measure on the other side.

We also acknowledge several limitations in our analysis. First, since the mass testing was on a voluntary basis, not everyone participated at the testing centers. Therefore, we cannot interpret the cost-effectiveness ratio as an indicator where testing was implemented on the whole population. Second, since we could not observe the age distribution of the population being tested, we inevitably could not account for the age-specific risks that are important for epidemic spread. Third, we obtained our QALY measure from existing literature, which is in the context of the UK. We used this widely adopted value because there is no robust estimation of quality-of-life measures for respiratory disease hospitalization and ICU discharges.

To conclude, this research has investigated the costs in cases where policymakers decide not to implement mass testing (i.e. non-intervention), focusing on incremental hospitalization costs from the perspective of the healthcare system and on the social burden in terms of working days and income lost. Specifically, we provide evidence on the cost-effectiveness and potential impact of mass COVID-19 testing on the local healthcare system and community. Although the intervention is shown to be cost-effective, we believe the initiative should be carried out when there is initial rapid local disease transmission with a high effective reproduction number, as shown in our model. Depending on the transmissibility of the variant, mass testing can become costly if a vast majority of the population is already infected. Moreover, policymakers need to collect in-depth information about prevalence by age or location for a more precise estimation of the benefit of such intervention. In the event of new pandemic outbreaks, our results can inform policymakers on the influence of intervention in a rapid growth scenario.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Data availability

SARS-CoV-2 data in Italy are provided by Italian Disaster Relief Agency (Protezione Civile) in a public repository that issues datasets at the following link: https://github.com/pcm-dpc/COVID-19/. Moreover, data about average wages in the Bozen/Südtirol province are available at ASTAT—provincial statistics institute (LandesInstitut fur Statistics) at the following link: http://www.provinz.bz.it/astat/preise-prezzi/PriceDigit.aspx?INDEX=CONS&lang=it. Last, all other data, provided by the LHC, are available online as Supplementary Material attached to this article.

Key points

- A few studies provide evidence about mass COVID testing of asymptomatic population living in a wide geographical area, using real-world data.
- The Italian Bolzano/Südtirol province's experience carrying out mass COVID testing provides evidence about the effectiveness of this strategy in breaking the chain of infections.
- From a healthcare system perspective, mass COVID testing is cost-effective compared with a non-intervention strategy in terms of incremental burden and cost of hospitalization.
- A mass COVID testing should be carried out when there is initial rapid local disease transmission with a high effective reproduction number, as shown in our model.

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