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Editorial

COVID-19: difficult transitions

It has been an amazing achievement that within the past two years, vaccines against COVID-19 have been both developed and rolled out globally en masse. To date, more than 10 billion doses of COVID-19 vaccine have been given to 61% of the world's population.[1] However, there is still a lot more work to be done as many still remain unvaccinated, particularly in low- and middle-income countries.

Encouragingly, vaccination has considerably reduced the risks of the very worst outcomes of infection such as severe disease requiring hospitalisation, mechanical ventilation and death.[2] Globally, COVID-19 case fatality rates have declined to less than 2% in many countries.[3] Whilst still more severe than seasonal influenza, in vaccinated individuals the COVID-19 infection fatality rates in some countries are now approaching low levels similar to influenza. If the link between infection and severe outcomes has been broken by immunisation, this raises the question as to whether pandemic control measures can be removed.

At some point in time, many of the public health measures implemented in the past two years could be lifted, but the key question is the pace and timing for this transition from pandemic mode to the post–acute pandemic phase. This involves a trade-off between the social and economic benefits versus the infection risks for the population. If the measures are lifted prematurely, resurgent infections could follow. However, the longer the restrictions are kept in place, the greater the economic damage caused. For example, the UK experienced a severe recession and 9.7% drop in its Gross Domestic Product in 2020 due to the pandemic.[4] There are also well-recognised social impacts such as reductions in personal well-being and greater anxiety.[5] Growing public weariness with pandemic measures may also adversely affect adherence to them.

Public health policymakers may find it increasingly difficult to justify and advocate for continuance of restrictive public health measures, against competing voices from politicians, businesses, industry, education and other groups. The coming months could be a hazardous and challenging time for public health, whose message may be cast as authoritarian, doom-mongering, out-of-touch and damaging to wider society. Public health practitioners may rapidly go from hero to public enemy.

How the profession communicates its narrative to the public and policymakers will therefore be key to navigating through these treacherous hazards. We cannot assume that public health evidence will be accepted at face value, nor can it be examined purely in health terms as ultimately it will necessitate a balance of restrictions versus freedoms. We are likely to find our judgements and decisions called into question by critics armed with hindsight, which is always easier than foresight.

The evidence and justification for each and every public health measure will be challenged. On its own, the evidence of benefit for each measure is likely to be limited, patchy and difficult to extricate from the confounding situation where many measures had been implemented throughout the course of the pandemic. Such an approach adopted by critics ignores the fact that no single intervention would have been sufficient for a challenging situation where a multilayered preventative approach was needed. Indeed, many public health measures had to be introduced on a precautionary basis, on the best evidence available at the time, however limited. That said, the relative protective value of non-pharmaceutical interventions in a highly vaccinated population may be less.

Transitioning out of the acute phase of the pandemic is especially tricky to manage as there are multiple views and interests at play. Each and every individual will have different risk appetites and tolerances, and there is no one-size-fits-all public health policy that will satisfy everyone. Vaccinated young persons for whom the disease in likelihoods will be mild may question the need and proportionality of the imposition of restrictions on them that limit their work, social and educational opportunities. Some older individuals who have suffered from the social isolation created by lockdowns and shielding may choose to prioritise and maximise their quality of life over quantity.

There will also be competing non-COVID-19 healthcare needs and demands, arising from healthcare activity that have been displaced and delayed by the response required of the pandemic. This includes elective healthcare, screening and prevention, as well as chronic disease management activities. Pandemic responses are expensive and draw on the same limited pool of health and care workers. There is an opportunity cost to maintaining the pandemic response infrastructure. In the UK, for example, the cost of the testing and tracing infrastructure was around £37 billion, accounting for a quarter of the total health budget.[6]

But whilst those countries with high vaccination coverage rates (who are mostly high-income countries) now contemplate transitioning to life beyond COVID-19, it is important to recognise that the pandemic has not ceased globally. Many countries remain in the grip of high levels of infections. Global vaccine inequity persists. Endemic disease may still cause high levels of ill health and mortality, which we know from bitter experience will disproportionately affect the poor, and especially vulnerable groups including the elderly and those with comorbidities, as well as marginalised groups such as the homeless, migrants and ethnic minority groups. Whilst winding down some of the pandemic response apparatus may be politically, socially and economically desirable, we have to ensure that there are measures in place to protect these vulnerable population groups.

Finally, there remains the very real possibility of new and emerging variants that may evade vaccine immunity and, unlike the Omicron variant, cause more severe disease and death. As Dr

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Tedros Ghebreyesus, the World Health Organization Director-General, warns, "it is dangerous to assume that Omicron will be the last variant or that we are in the endgame. On the contrary, globally the conditions are ideal for more variants to emerge".[7] Neither will vaccinations alone prevent infections and contain outbreaks.[8] So whilst countries may be de-escalating their pandemic response, they need to continue to be vigilant and retain their ability to mobilise and re-escalate to tackle any emergent threat.[9] It would be unwise to expect a return to a prepandemic world with no measures.

Author statements

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Short Communication

Educational inequalities in risk perception, perceived effectiveness, trust and preventive behaviour in the onset of the COVID-19 pandemic in Germany

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ABSTRACT

Objectives: This study analysed educational inequalities in risk perception, perceived effectiveness, trust and adherence to preventive behaviours in the onset of the COVID-19 pandemic in Germany.
Study design: This was a cross-sectional online survey.
Methods: Data were obtained from the GESIS Panel Special Survey on the coronavirus SARS-CoV-2 Outbreak in Germany, including 2949 participants. Stepwise linear regression was conducted to analyse educational inequalities in risk perception, perceived effectiveness, trust and adherence to preventive behaviours considering age, gender, family status and household size as covariates.
Results: We found lower levels in risk perception, trust towards scientists and adherence to preventive behaviour among individuals with lower education, a lower level of trust towards general practitioners among individuals with higher education and no (clear) educational inequalities in perceived effectiveness and trust towards local and governmental authorities.
Conclusion: The results underline the relevance of a comprehensive and strategic management in communicating the risks of the pandemic and the benefits of preventive health behaviours by politics and public health. Risk and benefit communication must be adapted to the different needs of social groups in order to overcome educational inequalities in risk perception, trust and adherence to preventive behaviour.

Introduction

Risk communication and adherence to preventive behaviour are core elements of the success of public health interventions to prevent and decrease the spread of infection diseases, such as the COVID-19. Since its official declaration as a pandemic in March 2020, Germany has undertaken different measures to prevent the spread of SARS-CoV-2 accompanied by the communication of risks of SARS-CoV-2.[1]

The successful containment of the pandemic by appropriate preventive behaviours and a support of public health measures strongly depends on risk perception, perceived effectiveness of interventions and trust towards individuals and institutions handling the pandemic. COVID-19-related studies suggest that individuals with low educational status show less COVID-19 preventive behaviours than others.[2–4] Moreover, single studies indicated lower risk perception, perceived effectiveness and trust among individuals with a lower educational status.[1,3,5,6]

This study builds on previous single studies and aims to analyse differences in risk perception, perceived effectiveness, trust towards different authorities and adherence to preventive behaviours by educational status in the onset of the COVID-19 pandemic in Germany. In contrast to previous studies, this study allows a direct comparison of educational differences of factors important for the successful containment of the pandemic. The main research question is whether risk perception, perceived effectiveness, trust towards different authorities and adherence to preventive behaviours differ by educational status and whether an adaption of public health strategies in communicating the risks of the pandemic and benefits of preventive behaviour is required.

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Methods

Study population

We used data from the GESIS Leibniz Institute for the Social Sciences panel's subsample of online respondents (n = 3186). Data for the present study were collected from 16 to 29 March 2020 – the onset of the pandemic in Germany – and included German-speaking individuals aged between 18 and 70 years.[7]

Measurements

Outcomes

Risk perception was measured by a sum score of five items. These capture the respondents' assessment of the likelihood that they or someone in their immediate environment would become infected with SARS-CoV-2, would need hospitalisation due to a SARS-CoV-2 infection, would need to be in quarantine or would infect other persons in the next 24 months (ranging from 0: 'not at all likely' to 7: 'absolutely likely'; Cronbach's alpha: 0.82).

Perceived effectiveness was measured by a sum score of seven items that captured respondents' perceptions of effectiveness against policy measures taken to close public and private sector facilities, ban visits to facilities with vulnerable groups and movement restrictions (ranging from 0: 'not effective at all' to 7: 'very effective'; Cronbach's alpha: 0.87).

As part of the survey, respondents were asked whether and to what extent they trust different authorities handling with the COVID-19 pandemic (ranging from 0: 'do not trust at all' to 4: 'trust completely'): the general practitioner, local authorities (local health authority, municipal and city administration), governmental authorities (Robert Koch Institute, Federal Chancellor, Federal Government, Ministry of Health) and scientists.

Preventive behaviour was measured by a sum score of eight items on behaviour to decrease risks of a COVID-19-infection in the past 7 days (Cronbach's alpha: 0.52): avoidance of certain places, maintaining a minimum distance, adjusting school and work situations, quarantine measures, more frequent and prolonged hand hygiene, use of disinfectants, stocking up on water and food, reduced personal contacts and wearing a face mask (response options: 'No' and 'Yes').

All outcomes were scaled on a range of 0–100.

Independent variables

Educational level was measured using the ISCED-97 scale (12) and was recoded into three categories (low, intermediate and high). Covariates were gender, age (ten 5-year categories), marital status (unmarried, married or in partnership, widowed and divorced) and household composition (one, two or three or more persons).

Statistical analyses

We excluded participants with missing information on variables for any of the considered variables (n = 2949). First, sample characteristics were described by percentages, mean levels and standard deviations (SDs). Second, stepwise linear regression was conducted in which education (M1), age (as continuous variable) and gender (M2), family status (M3) and household size (M4) were successively included in the models. The degree of model fit was assessed with R^2.

Results

The study population included 51.2% men and 48.8% women. The proportions of age groups ranged from 2.3% (aged <25 years) to 26.7% (aged 51–65 years). Overall, 66.3% of the respondents were married, 22.2% unmarried, 7.7% divorced and 3.7% widowed. Moreover, 48.5% lived in a two-person household, 40.3% in a household with three or more household members and 11.2% in a single household. A total of 10.9% of the respondents had a low, 31.4 had an intermediate and 57.7% had a high educational status. The mean level of risk perception was 50.7 (SD: 17.3), of perceived effectiveness 79.1 (SD: 16.9), of trust towards general practitioner 78.7 (SD: 23.1), of trust towards local authorities 65.5 (SD: 21.4), trust towards governmental authorities 71.7 (SD: 21.5), of trust towards scientists 80.9 (SD: 19.9) and of adherence to preventive behaviour 49.6 (SD: 15.8).

Compared with respondents with high educational status, lower educated respondents had a significantly decreased risk perception, trust towards scientists and adherence to preventive behaviour, independently from model specification (see Table 1). For trust towards governmental authorities, the results showed significant lower values for respondents with an intermediate educational status; significant differences between high and low educated respondents were not found. A reversed educational gradient was observed for trust towards general practitioners with significantly higher trust levels for intermediate and low educated respondents compared with high educated respondents. No clear significant educational inequality was found for perceived effectiveness and trust towards local authorities.

In the regression analyses, some of the sociodemographic factors were related to the outcomes considered (see Supplementary Tables S1–S7). Older individuals were significantly more likely to report lower risk perception and prevention behaviours but consistently had higher trust scores. Women were significantly more likely than men to perceive containment measures as effective and to report higher levels of trust in local and government authorities and to engage in prevention behaviours. Finally, singles, in contrast to married individuals, had significantly lower risk perceptions, lower perceived effectiveness and lower trust in local authorities and prevention behaviours. In addition to educational status, the associations found were particularly strong for age and gender.

Discussion

Main findings

We found lower levels in risk perception, trust towards scientists and adherence to preventive behaviour among individuals with lower education. There was a lower level of trust towards general practitioners among individuals with higher education and no (clear) association of educational status with perceived effectiveness of containment measures and trust towards local and governmental authorities.

The finding of significant associations of educational status with risk perception, trust towards scientists and adherence to preventive behaviour complies with other studies.[1,3,8] However, as this study was conducted in the onset of the pandemic in Germany, associations might have changed over time as shown in the study of Rattay et al.[1] Moreover, lower education was associated with lower levels of trust towards scientist, which might be explained by a lower scientific knowledge of lower educated individuals and an inadequate communication of scientific evidence to lower educated individuals.[9] We found higher levels of trust towards general practitioners among lower educated individuals as found in a study among U.S. cancer patients.[10] This might be explained by a generally higher tendency of people with a lower education to not question the medical profession's actions. Finally, perceived effectiveness of containment measures was generally at a higher level and did not significantly vary by educational status, which undermines the general trust towards the efficacy of local and governmental measures in terms of COVID-19. Moreover, age, gender and family were

Table 1
Stepwise linear regression for risk perception, perceived effectiveness, trust and adherence to preventive behaviour by educational status (GESIS Online Panel 2020, n = 2949).

Model (M)	Risk perception	Perceived effectiveness	Trust towards				Adherence to preventive behaviour
			General practitioner	Local authorities	Governmental authorities	Scientists	
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
M1							
High educational status	*Reference category*						
Intermediate educational status	−2.6*** (−3.9, −1.2)	1.2 (−0.1, 2.6)	3.6*** (1.8, 5.5)	2.2* (0.5, 3.9)	−1.6 (−3.3, 0.1)	−2.4** (−4.0, −0.8)	−2.8*** (−4.0, −1.5)
Low educational status	−5.6*** (−7.6, −3.5)	−0.2 (−2.2, 1.8)	5.7*** (3.0, 8.5)	3.5** (0.9, 6.0)	−1.0 (−3.5, 1.6)	−2.9* (−5.2, −0.5)	−4.7*** (−6.6, −2.9)
R^2	0.012	0.001	0.009	0.004	0.001	0.004	0.012
M2							
High educational status	*Reference category*						
Intermediate educational status	−1.1 (−2.5, 0.2)	0.9 (−0.5, 2.3)	1.8 (−0.0, 3.7)	1.3 (−0.4, 3.0)	−2.9** (−4.6, −1.1)	−2.9*** (−4.5, −1.3)	−2.9*** (−4.1, −1.6)
Low educational status	−3.3** (−5.4, −1.3)	0.1 (−1.9, 2.1)	3.0* (0.2, 5.7)	2.7* (0.1, 5.2)	−2.3 (−4.9, 0.3)	−3.6** (−6.1, −1.2)	−4.2*** (−6.1, −2.3)
R^2	0.055	0.020	0.044	0.015	0.022	0.010	0.036
M3							
High educational status	*Reference category*						
Intermediate educational status	−1.2 (−2.6, 0.2)	0.8 (−0.6, 2.2)	1.9* (0.1, 3.8)	1.3 (−0.4, 3.1)	−2.8** (−4.6, −1.1)	−2.7** (−4.3, −1.1)	−3.0*** (−4.3, −1.7)
Low educational status	−3.3** (−5.4, −1.3)	0.2 (−1.9, 2.2)	3.2* (0.4, 6.0)	2.7* (0.1, 5.3)	−2.2 (−4.8, 0.4)	−3.5** (−5.9, −1.0)	−4.1*** (−6.0, −2.2)
R^2	0.058	0.024	0.046	0.015	0.028	0.013	0.044
M4							
High educational status	*Reference category*						
Intermediate educational status	−1.2 (−2.6, 0.2)	0.8 (−0.6, 2.2)	1.9* (0.1, 3.8)	1.3 (−0.4, 3.1)	−2.9** (−4.6, −1.1)	−2.7** (−4.3, −1.1)	−3.0*** (−4.3, −1.7)
Low educational status	−3.3** (−5.3, −1.2)	0.2 (−1.8, 2.2)	3.1* (0.4, 5.9)	2.6* (0.0, 5.2)	−2.3 (−4.9, 0.3)	−3.5** (−5.9, −1.1)	−4.0*** (−5.9, −2.1)
R^2	0.058	0.024	0.047	0.017	0.029	0.013	0.046

CI, confidence interval; M1, bivariate model; M2, M1 + age and sex; M3: M2 + family status; M4: M3 + household type.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

significantly related to risk perception, perceived effectiveness, trust and adherence to preventive behaviours, which is in line with previous studies.[1,3–6] To reach individuals with a low educational status as well as other social groups, planned risk management by leadership in times of pandemic is necessary.[11]

Methodological issues

It is an asset that we used data from a representative population-based survey conducted at the onset of the COVID-19 pandemic. One limitation of this study is the lack of information on pandemic knowledge that might strongly interrelate with risk perception, perceived effectiveness and adherence to preventive behaviour. As the survey was conducted at the onset of the pandemic and cross-sectionally, we were not able to analyse how appraisals might have changed over the course of the pandemic. Moreover, the interpretation of the results and the level of disparities found by educational status may be influenced by the scaling of the outcome variables as well as by the different response categories of the raw items of the respective outcomes. Scaling the variables to an index from 0 to 100 allows for a comparison of coefficients across the outcome variables but permits only imprecise conclusions about how strong the disparities found are for a single outcome. Moreover, the comparability of the outcomes may be affected by the different response categories of the raw items, for example, by a different response pattern. Finally, it is known that some of the used outcomes may depend on factors, such as income, health status or personal traits, which have not been surveyed and may explain the low explained variance found in our study.[1,3,5,6]

Implications

The study indicates educational inequalities in risk perception, trust towards scientists and adherence to preventive behaviour in the onset of the COVID-19 pandemic in Germany. The results underline the relevance of a comprehensive and strategic management in communicating the risks of the pandemic and the benefits of preventive health behaviours by politics and public health. Risk and benefit communication must be adapted to the different needs of social groups to overcome educational inequalities in risk perception, trust and adherence to preventive behaviour.

Author statements

Ethical approval

Not required. This study analysed anonymised data for scientific purposes.

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Competing interests

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.02.021.

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Short Communication

Endemic fatalism and why it will not resolve COVID-19

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ABSTRACT

Objective: The main objective of this commentary is to provide historical insight into the term endemicity and to demonstrate why framing COVID-19 as endemic in early 2022 is a misguided approach.
Study design: The history of epidemiology as well as current data on COVID-19 as provided by the United States Centers for Disease Control, the World Health Organization, and the Johns Hopkins COVID-19 Resource Center was surveyed.
Methods: Records of the Epidemiological Society of London for the period 1850–1900 were analyzed, and several key publications on how infectious diseases were considered endemic were identified.
Results: The term endemicity has a long and twisting history, changing from its meaning in the mid-nineteenth century until our use of it today. The concept has long been tied to historical patterns of colonialism.
Conclusion: Framing COVID-19 as an endemic disease in early 2022 is a misguided attempt and a result of cultural and political forces.

Pandemic fatigue has been pushed aside by a new phenomenon in many places around the world: endemic fatalism. The raging Omicron variant of COVID-19 has ushered in the highest case positivity rates since the beginning of the pandemic, flooding hospitals and attacking even those vaccinated and boosted against the disease. “We’re all going to get it” is a phrase now heard almost daily. Omicron has in many ways shifted the narrative of COVID-19. Against this backdrop has emerged a new idea that COVID-19 is transitioning from a pandemic to an endemic disease. Spain’s Prime Minister Pedro Sanchez, for example, publicly asserted that the European Union should reduce surveillance, testing, and quarantine periods and treat COVID-19 more like the seasonal flu than a deadly pandemic. This is against the backdrop of COVID-19 cases rising 48% worldwide in just one week, shattering previous records even in countries that have been relatively successful at keeping the disease at bay, such as Australia and Japan.

What's fueling the push to see COVID-19 as endemic, and what's at stake in treating COVID-19 more like the flu, a not-so-subtle shift that health experts have warned against for the past two years? In part the answer stems from the misplaced idea that while Omicron is more contagious than the previous strains of the disease such as the Delta variant, it is less virulent. The United States Centers for Disease Control, for example, reported this week that the Omicron variant has 53% less risk of hospitalization and 91% less risk of death than the Delta variant. This has led many people to think that Omicron is spreading so rapidly around the world, hitting both the vaccinated and the unvaccinated, that we will reach collective herd immunity in short order. Seeing COVID-19 as endemic, in other words, might mean an end to the pandemic.

But reframing COVID-19 as an endemic disease right now is a premature notion at best, representing more of what we want COVID-19 to become than the epidemiological reality we face today. The truth is that hospitals around the world are near capacity, percentage-wise, with more children younger than five years than we have seen throughout the pandemic. Healthcare workers, parents, and those individuals immunocompromised are strained beyond measure after two years of physical and mental hardship. It makes sense that we want to see COVID-19 become a milder disease similar to the seasonal flu: seasonal, predictable, less virulent.

But the evolutionary trajectory of COVID-19 does not at this time suggest a clear path toward endemicity, and epidemiologists and evolutionary biologists warn against impulsively applying this notion to the disease. The seasonal flu, for example, operates on the principle of ‘antigenic turnover,’ where variants of the disease typically arise from prior variants. COVID-19 has not behaved in this manner; Omicron is not an offspring of Delta, and

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not all disease models function on the pattern whereby a new disease must always evolve toward lowered virulence. Take, for example, Ebola. The facts are that we just don't know what Omicron will do to shape global levels of immunity; we certainly don't know what other strains of COVID-19 will lie in the months, weeks, and years ahead.

A historical dive into the term endemic, though, may help us to see the faults of reframing COVID-19 as endemic right now. Although the term was occasionally used in the 18th century, by the mid-19th century, a period that saw the rise of the modern field of epidemiology, endemic was frequently used when thinking about infectious disease. Derived from the Greek words 'in' and 'people,' epidemiologists by the 1850s used endemic to mean diseases that regularly occurred in particular locations. At a time when scientific experts believed that some diseases could erupt spontaneously given the right mix of environmental conditions, the term endemic was tied to terrestrial and soil-based notions of disease. Intimately linked to the term endemic was its counterweight, epidemic, which meant an imported, and often it was believed, contagious disease.

The publicly stated objects of the Epidemiological Society of London, the oldest organization of its kind which began in 1850, was the study of both epidemic and endemic diseases and the relationship between the two. These were connected terms, not oppositional ones, and a disease such as cholera was considered both endemic and epidemic at the same time.

Distinguishing endemic from epidemic was a way to explain the geographical distribution of disease around the world, no doubt, but it was also fueled by 19th century colonialism. At the 1859 presidential address of the Epidemiological Society, president Benjamin Guy Babington implored that "cholera has now been so long regarded as an established endemic of India, that we now hear of its appearance in different localities in that country without surprise, and with comparatively little interest".[1] Framing cholera as endemic to India was a way to scapegoat the origin of the disease to a far-away land and people: 'them' not 'us.' Malaria and yellow fever were seen to be 'endemic' to the tropics, and plague to Southeast and East Asia. Built into the idea of an endemic disease in this era was also a way to explain the rise, distribution, and spread of an epidemic disease. As Babington continued in his 1859 speech on cholera, "it is otherwise when this terrible invader approaches nearer home. We then begin to consult maps, and to compare dates and seasons, in order to ascertain how far the disorder, in respect to its period of invasion, its march, and its mortality, coincides in character with that which it exhibited during its former visits to Europe".[2]

Framing a disease as either endemic or epidemic, then, has also been about fitting a political and cultural agenda. As John Macpherson, Inspector-General of Hospitals in Bengal, India, noted in 1867, "no question in medicine is more interesting than that of an endemic disease taking on the character of an epidemic, and of the behaviour of an endemic, when its own epidemic form reaches it".[3]

By the 1880s with the rise of the germ theory, the notion of an endemic disease began to subtly change to mean a disease present in a location through human-to-human or animal-to-human reservoirs, but one that could for human, animal, or environmental reasons erupt into an epidemic or even a pandemic. Cholera, plague, and typhoid served as models for this new type of thinking. All three had begun to decline in Europe and North America and in the process were labeled as endemic to what we now call the Global South. And the culture wars still raged, in particular with the founding of the World Health Organization and Western-inspired attempts at global health.

The question that came to dominant epidemiologists, ecologists, and evolutionary biologists in the twentieth century was the reasons why an endemic disease might suddenly erupt into an epidemic one. Already by the late 19th century, some experts suggested environmental, evolutionary, and human-animal zoonotic reasons, though even today this question still dominates research into infectious disease.[4] What is clear from even a cursory historical examination of the concept of endemicity is that there are cultural and political and not always scientific reasons for labeling a disease endemic. By the mid-20th century, the term endemic became more oppositional to the term epidemic, and experts in the Global North considered cholera, typhoid, and plague to be diseases endemic to the Global South—out of sight, out of worry. But these diseases, particularly cholera and typhoid, continue to ravage human populations. Western notions of endemicity have enabled those in the Global North to neatly shelf the diseases as problems of economic development. A similar phenomenon happened in the 1990s with HIV/AIDS, when that disease was reframed as endemic, something similar to diabetes in the US and Europe even while it stormed—and continues to storm countries such as South Africa.

Is the Omicron variant an excuse to do the same thing to COVID-19? If so, it seems at best like welcoming endemicity is a neoliberal apology for the failure of most government's ability to properly handle COVID-19 for the past two years. At its worst, this view is a Neodarwinian fatalism; more need to die before we can get back to 'normal.' We should stand against both and be more concerned with putting into place measure we know work to mitigate the spread of the disease. More so than even that, we need to see endemics something like the mid-Victorian epidemiologists saw them, save the cultural imperialism, as intimately connected to epidemics. Edward Goodeve, for instance, the British representative to the 1866 International Sanitary Conference, recommended that cholera had 'endemic centers' which served as the 'starting points' of epidemics. "What may be called the endemicity of cholera," he argued, "is little more than a prolonged epidemic".[5] We may be faced with something eerily similar with COVID-19.

Author statements

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This study did not require any ethical approval or human-based research. As a historical analysis, it did not involve a human trial or research participants.

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Short Communication

From contact tracing to COVID-19 pass holder; the tortured journey of the French TousAntiCovid contact tracing app

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ABSTRACT

Objectives: Our study aimed to provide an updated overview of the use of the French contact tracing application, TousAntiCovid, and identify evolutions since the beginning of the pandemic.
Study design: We conducted a survey study on a representative sample of the French adult population.
Methods: Our data were collected by the Obervatoire Régional de la Santé (ORS) using a self-administered online questionnaire. This was completed by a sample of 2,022 people stratified to match French official census statistics for gender, age, occupation, and area of housing. We conducted statistical analysis using Python (Pandas – Scipy - Statsmodels) with chi-squared and Wilcoxon rank-sum tests to control for statistical significance.
Results: A small majority of respondents used TousAntiCovid (55.5%), while 41.0% had never downloaded it. Only one-quarter of the respondents (23.3%) used it for contact tracing with Bluetooth, while a third (32.2%) used it only for storing their health pass. The app's use increased with education level, income, and younger age. A large majority (85%) of non-vaccinated respondents had never downloaded TousAntiCovid.
Conclusion: Our results suggest that the role and use of France's official COVID-19 app TousAntiCovid has evolved in line with the government's strategy; while initially focusing on contact tracing, its development has led to the possibility to store test and vaccination documentation. The survey also confirmed previous results pointing to the lasting differences in socio-economic status in terms of adoption of the app. This is problematic because the long-term nature of the pandemic could require the government to keep a range of strategies open, including contact tracing. Public discussion of the current and future roles of the French contact tracing app is therefore needed.

Introduction

The spread of new SARS-CoV-2 variants, especially Omicron, is a serious challenge for the current vaccine strategy and calls for complementary public health measures. Contact tracing offered the promise of a microlevel management of virus transmission.[1] Different types of contact tracing apps have been implemented in numerous Europe countries since the beginning of the COVID-19 pandemic.[2] In some countries, the use of contact tracing apps is based on voluntary adoption and is consequently largely dependent on communication by the government. Among them, the case of France stands out since the governmental strategy focused on vaccination and largely abandoned the communication regarding contact tracing while continuing to maintain the apps. After its announcement in 2020[3] followed by an initial failure in uptake, the French contact tracing app saw both its development strategy and its name change (from StopCovid to TousAntiCovid). Although described as an historical success by a spokesperson for the French government, the app had almost disappeared from public communications by the end of 2020

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before returning with the introduction of the COVID-19 health pass in the summer of 2021.[4] Adding to its contact tracing function, the new version of the app can store multiple QR codes (for proof of negative tests, of vaccination, and of recovery) and was '*enhanced by access to factual information and health information on the pandemic.*'[5] In early December 2021, it was decided to extend app support until 31 July, 2022. Due to the fast-paced evolution of the pandemic, there is a need of an updated picture of these apps' current use, especially regarding prior results that pointed out the relation with the political management of the pandemic.[6]

Methodology

In early December 2021, we conducted a survey on a representative sample of the adult French general population (N = 2022). We asked questions on the use of the TousAntiCovid app ('Have your ever downloaded a contact tracing app as TousAntiCovid during this pandemic?' Response options were as follows: 'Yes, and I use it with Bluetooth for contact tracing'; 'Yes, but I only use it to store my health pass'; 'Yes, but I removed it', 'No, I have never downloaded it') as well as respondents' intention to vaccinate against COVID-19. We also asked questions about political engagement and trust in institutions, two factors that appear to have had strong effects on health behaviors during the present pandemic. Indicator of trust was calculated with dichotomizing 10 questions regarding trust in various institutions, with 1 if respondents expressed trust, summing it and calculating quartiles.

Results

We found that a small majority of respondents used TousAntiCovid (55.5%), while 41.0% had never downloaded it (Table 1). Furthermore, only one-quarter of the respondents (23.3%) used it for contact tracing with Bluetooth, while a third (32.2%) used it only for storing their health pass.

The app's use increased with education level, income, and younger age. Using it for contact tracing ranged from 19% of the low-income respondents to 32% for high-income ones. Also to note, 40% and 39% of younger respondents and persons with a third-level education qualification used it only to store their health pass, respectively.

Above all, our survey shows that the use of contact tracing apps cannot be isolated from the rest of the current pandemic management policy. A large majority (85%) of non-vaccinated respondents had never downloaded TousAntiCovid. Moreover, political orientation had a tremendous influence; specifically, 72% of respondents who felt close to parties at the center of the political spectrum reported using the app compared to 46% and 49% of respondents close to the far right and far left, respectively. Furthermore, only a quarter (26%) of respondents with a great deal of trust in institutions and science had not downloaded TousAntiCovid.

Table 1
Use of TousAntiCovid app according to respondents' characteristics (N = 2022).

Variable	Modality	1-Yes, and I use it for contact tracing	2-Yes, but I only use it to store my health pass	No, I have never downloaded it	Yes, but I removed it	Proportion
Gender (**)	Man	253.9 (26.4%)	318.8 (33.1%)	359.2 (37.3%)	30.6 (3.2%)	46.1%
	Woman	216.6 (20.4%)	333.0 (31.4%)	472.9 (44.6%)	37.0 (3.5%)	53.9%
Age (years) (***)	18–34	79.0 (15.7%)	205.2 (40.7%)	196.5 (39.0%)	23.3 (4.6%)	25.0%
	35–49	113.1 (23.2%)	158.2 (32.4%)	193.1 (39.6%)	23.2 (4.8%)	22.3%
	50–64	127.2 (25.8%)	148.7 (30.2%)	207.2 (42.0%)	9.8 (2.0%)	25.2%
	65–100	151.1 (28.1%)	139.7 (26.0%)	235.3 (43.8%)	11.4 (2.1%)	27.4%
Level of education (***)	Lower than USS certificate	243.7 (23.4%)	283.7 (27.2%)	482.3 (46.3%)	32.4 (3.1%)	51.3%
	USS certificate	49.0 (27.7%)	52.3 (29.6%)	65.9 (37.3%)	9.5 (5.4%)	8.6%
	Higher than USS	177.8 (22.1%)	315.8 (39.3%)	283.9 (35.3%)	25.8 (3.2%)	40.1%
Monthly income (***)	0-1000€	36.4 (19.2%)	48.3 (25.5%)	92.3 (48.8%)	12.1 (6.4%)	8.8%
	1000-2000€	104.2 (18.8%)	159.9 (28.9%)	265.1 (47.9%)	24.8 (4.5%)	27.6%
	2000-4000€	200.2 (25.3%)	292.4 (36.9%)	282.0 (35.6%)	18.1 (2.3%)	39.7%
	4000€ and over	80.4 (32.3%)	84.5 (33.9%)	78.3 (31.4%)	6.1 (2.4%)	12.3%
	NA	49.3 (20.8%)	66.7 (28.2%)	114.4 (48.3%)	6.4 (2.7%)	11.6%
Indicator of general trust (***)	Q1 - Low	80.8 (12.8%)	156.4 (24.8%)	363.7 (57.7%)	29.6 (4.7%)	31.1%
	Q2	97.9 (19.6%)	166.7 (33.4%)	213.5 (42.8%)	20.5 (4.1%)	24.8%
	Q3	121.0 (29.4%)	150.5 (36.5%)	127.6 (31.0%)	13.1 (3.2%)	20.4%
	Q4 - High	170.8 (35.5%)	178.1 (37.1%)	127.3 (26.5%)	4.4 (0.9%)	23.6%
Vaccin status (***)	Already vaccinated or in favor	467.9 (25.8%)	637.3 (35.2%)	652.7 (36.0%)	52.9 (2.9%)	89.8%
	Not vaccinated and against vaccination	2.6 (1.2%)	14.5 (6.9%)	179.4 (84.9%)	14.7 (7.0%)	10.2%
Political orientation (***)	Center	110.9 (40.0%)	88.2 (31.8%)	75.1 (27.1%)	3.3 (1.2%)	13.7%
	None	10.8 (17.5%)	27.5 (44.6%)	22.1 (35.9%)	1.2 (1.9%)	3.0%
	Left	89.0 (28.7%)	99.6 (32.1%)	116.9 (37.7%)	4.8 (1.5%)	15.5%
	Right	59.7 (27.3%)	75.7 (34.6%)	77.7 (35.5%)	5.9 (2.7%)	10.9%
	Far left	52.1 (21.0%)	69.3 (28.0%)	105.9 (42.7%)	20.5 (8.3%)	11.7%
	Far right	52.1 (17.8%)	82.6 (28.2%)	150.6 (51.5%)	7.3 (2.5%)	14.7%
	Other	95.8 (15.6%)	208.9 (34.1%)	283.8 (46.3%)	24.6 (4.0%)	30.4%
Total		470.5 (23.3%)	651.8 (32.2%)	832.1 (41.2%)	67.6 (3.3%)	2022 (100%)

Percentage per line, for example, 26.5% of the men downloaded the app and use it for contact tracing.
Statistical significance of two-sided $\chi 2$ tests: (***), $P < 0.001$; (**), $P < 0.005$; (*), $P < 0.01$.
Absolute counts are expressed with a decimal because of the weighting procedure used.
Acronyms: USS, upper secondary school; NA, not answered; Q, quartile.

Discussion

Contract tracing appears to have efficacy in the fight against the COVID-19 pandemic,[7] yet more evaluation is needed for contract tracing app,[8] especially for countries which chose a voluntary-based adoption. Moreover, there is a need to take into account the broader picture of pandemic management since trust in the government is a strong predictor of its uses,[6] as it is for attitudes toward vaccination and the health pass.[4]

Our results suggest that the role and use of France's official COVID-19 app TousAntiCovid has evolved in line with the government's strategy; while initially focusing on contact tracing, its development has led to the possibility to store test and vaccination documentation. The survey also confirmed previous results pointing to the lasting differences in socio-economic status in terms of adoption of the app.[3]

This shift can be interpreted in two contrasting ways: as a failure of the 'nearly forgotten' contact tracing strategy or as an innovative way to develop the app's capabilities to change its use and possibility its usefulness. The app's failure is reflected in the very small proportion of the French population using it for its contact tracing feature. The probable main reason for this is the lack of communication from the government, which is now focusing all its efforts on vaccination. This is problematic because the long-term nature of the pandemic will require the government to keep a range of strategies open. Public discussion of the current and future roles of the French contact tracing app is therefore needed.[9]

In terms of innovation, the current uses of TousAntiCovid provide a perspective of what the app is evolving into: a dedicated management tool for storing documents and a source of access to public health content. This evolution suggests the possibility of creating a new channel of communication between health authorities and citizens regarding changes in the pandemic and related health protocols and polices. However, one of the strongest arguments against their use is the concern over their technical limitations and the risk of data security breaches.[10] For this reason, any transformation of digital devices for public health purposes requires vigilance, as new functions tend to create flaws in security and concerns about data privacy, which in turn can erode general public trust and the perceived legitimacy of communicated information.

Author statements

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Competing interests

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Letter to the Editor

Highly efficient respirators are needed for the Omicron variant of SARS-CoV-2

We read with interest the recent letter of Lowe et al., [1] who concluded that face masks provide an essentially cheaper and straightforward means for minimizing the infection risk of severe acute respiratory coronavirus 2 (SARS-CoV-2),[1] especially now that the new and highly infective Omicron variant has become prevalent and dominant worldwide. Nevertheless, some additional aspects can be brought in support of this conclusion. First, we have recently shown that the nasopharyngeal viral load in patients infected by the Omicron variant is up to fourfold higher compared with those previously infected by other SARS-CoV-2 lineages,[2] which would make the adoption of physical interindividual barriers (such as face masks) more compelling than before. The second important aspect concerns the type of mask used for preventing infections. A recent meta-analysis has estimated that the efficacy of medical or surgical masks against the risk of SARS-CoV-2 infection is around 30%, whereas that of N95 or equivalent masks is as high as 70%.[3] In keeping with recent data attesting that the volume of exhaled viral particles is magnified in patients infected by the Omicron lineage,[4] it seems hence advisable not only to reinforce a mask-wearing advice but also to suggest that more efficient respirators (such as N95 or similar) would be preferable to grant major protection against highly infective SARS-CoV-2 lineages such as Omicron.

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Letter to the Editor

Mutual recognition of COVID-19 vaccine to restore normal social activities and redistribute vaccines for the next stage of the pandemic

As of December 2021, over 281 million coronavirus disease 2019 (COVID-19) cases were reported worldwide and more than 8 billion vaccine doses were administered to the population.[1] Although an increasing trend of vaccination is observed, with the recovery of economy and various international travel restrictions, a new challenge has emerged and affects the daily lives of many who intend to travel abroad.

Millions received vaccines at their home country prior to international travel; however, not all COVID-19 vaccines have been issued World Health Organization (WHO) Emergency Use Listing Procedure (EUL) qualification, which render them poorly recognized on a global scale.[2] As a result, people who did not receive WHO EUL vaccine may need to restart the standard primary doses. For example, the Centers for Disease Control and Prevention recommends those who have not received the complete WHO-EUL COVID-19 primary series should be offered primary vaccinations with Food and Drug Administration (FDA)—approved/FDA-authorized vaccine.[3] Additionally, the effectiveness and risk of mixing of different vaccinations and boosters from different countries remain uncertain due to the lack of sufficient data. This causes confusion to the general public, especially for those who recent traveled from a different country but need another booster dose. As healthcare providers, we have been asked many times if people should get their boosters only or if they should receive the WHO EUL primary dose series even though they have already been vaccinated in their own home countries. Meanwhile, another paradoxical inequality surfaced as the populations in underserved countries await their primary doses of protection, while the developed worlds are monopolizing the use of life-saving vaccine through unjustifiable extravagance by repeating vaccine series due to a lack of mutual recognition,[2–5]

In addition, due to a lack of enough international cooperation and research transparency in investigating the mixture of vaccines from different countries, healthcare agencies in some parts of the world may require the travelers to obtain certain series of vaccines and testing upon entrance.[2,6,7] The controversy is that, however, some travelers are unable to comply with these requirements or acquire the listed vaccine series as they are denied access per home country policies.

In conclusion, to accelerate the recovery of the economy and to restore international travel, researchers and international cooperation is urgently needed to investigate the mixture of different vaccines. It is also crucial for healthcare agencies and authorities to collaborate closely for mutual approval of COVID-19 vaccines manufactured in different countries.

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Short Communication

SARS-CoV-2 transmission dynamics in the urban-rural interface

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ABSTRACT

Objectives: As the world responds to the coronavirus outbreak, the role of public health in ensuring equitable health care that considers the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) dynamics in rural communities is still a challenge. The same suppression and mitigation measures have been implemented homogeneously, ignoring the differences between urban and rural areas. We propose an epidemiological model and simulate the dynamics of SARS-CoV-2 in urban and rural areas considering the interaction between these regions.
Study design: This was a population modeling study.
Methods: A compartmental epidemiological model was formulated to simulate the transmission of SARS-CoV-2 in urban and rural areas. We use the model to investigate the impact of control strategies focused on the urban-rural interface to contain the epidemic size of SARS-CoV-2 in rural areas.
Results: Considering five different levels for the exposition rate in urban areas and keeping intrarural and urban-rural exposition rates fixed, the preventive measures reduce the size and delay the peak for the urban infectives. The response of infected individuals and cumulative deaths in rural areas upon changes in the urban dynamics was small but not negligible. On the other hand, preventive measures focused on the urban-rural interface impact the number of infected individuals and deaths in rural areas.
Conclusions: The maintenance of SARS-CoV-2 in rural areas depends on the interaction of individuals at the urban-rural interface. Thus, restrictive measures established by the governments would not be required within rural areas. We highlight the importance of focused preventive measures on the urban-rural interface to reduce the exposure and avoid the transmission of SARS-CoV-2 to rural communities.

Introduction

Since the declaration of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) as a pandemic, different prevention and control strategies to slow the spread of this virus have been implemented worldwide.[1] These strategies have been commonly grouped into two approaches: *i*) suppression, which involves shutdowns for extended periods generating considerable social and economic costs, and *ii*) mitigation, which includes a combination of social distancing, large-scale viral testing, and symptomatic case isolation maintaining hospital burden at controllable levels.[2]

Various elements support that disease prevention measures should not be the same for urban and rural areas mainly due to the characteristics of rural communities, such as the inability to perform remote activities, lower contact rates, shortages of physicians and other healthcare providers, and a disproportionate number of older, poor, and underinsured individuals.[3] Indeed, despite the importance of rural communities and their interaction with urban areas,[4] specific SARS-CoV-2 prevention measures have not been established for these populations. Clearly, suppression measures are not feasible in rural communities, and additionally, mitigation measures would require epidemiological systems with high surveillance capacity, which seems impractical in the face of the imperfect health systems of rural areas.[5] Therefore, there is a need to understand the dynamics of SARS-CoV-2 in rural communities and establish strategic measures to avoid the transmission of the virus and the occurrence of deaths in these communities. To the best of our knowledge, there is so far little evidence of how disease control strategies should be focused to prevent cases in rural communities. To address this gap, we propose an epidemiological model describing the dynamics of SARS-CoV-2 infection in rural communities. Our model also includes the intrinsic transmission dynamics of urban areas, as well as the urban-rural interface.

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We find that due to the low interaction rate between individuals in rural communities, the maintenance of SARS-CoV-2 depends on the interaction of individuals when marketing products and carrying out activities at the urban-rural interface. Thus, preventive measures focused on the urban-rural interface reduce the size and delay the time of the peak in rural areas. In this way, the restrictive measures established by the governments would not be required within rural areas. This work can support public health decisions proposing the implementation of heterogeneous strategies focused on reducing the impacts of the SARS-CoV-2 pandemic in rural communities.

Methods

The proposed method is an adaptation of the classic homogeneous Susceptible-Exposed-Infectious-Recovered (SEIR) epidemic model to analyze infectious disease dynamics, which has a definite latent period, and has proved to be predictive for a variety of acute infectious diseases.[6] Since no realistic model will depict human populations as homogeneous,[2] in our modeling framework (Fig. 1) the population is divided into different compartments according to the residence (urban or rural) and the infection status of individuals: susceptible (S; at risk of contracting the disease), exposed (E; infected but not yet infectious), infectious (I; capable of transmitting the disease), detected (D; infectious confirmed by laboratory diagnostic test), recovered (R; those who recover from the disease), and death (F; those who die from the disease). Additionally, our model considers the interaction of people who reside in urban and rural areas and carry out commercial activities in the urban-rural interface. Given this classification, individuals are exposed to the virus and therefore become infected at different rates of exposure and infection.

The proposed urban-rural (SEIDFR) model considers that susceptible individuals can reside in urban (u) or rural (r) areas and that a proportion of these carry out activities at the urban-rural interface. Thus, susceptible individuals living in rural areas (S^r) are exposed to SARS-CoV-2 at the urban-rural interface through contact with infected individuals living in urban areas (I^u). Similarly, susceptible individuals living in urban areas (S^u) are exposed to SARS-CoV-2 through contact with other infected individuals residing in urban areas (I^u) or at the urban-rural interface through contact with infected rural individuals (I^r). Due to the low contact rate reported in rural areas,[2] the exposure rate to SARS-CoV-2 among people residing in rural areas is not considered. Once infectious, individuals can be diagnosed and detected by the national health system in both urban (D^u) and rural (D^r) areas. Additionally, these individuals can die in urban (F^u) or rural (F^r) areas or get recovered from the disease (R) (Supplementary Fig. 1).

Our model can be written as a system of differential equations following the heterogeneity associated with the activities at the

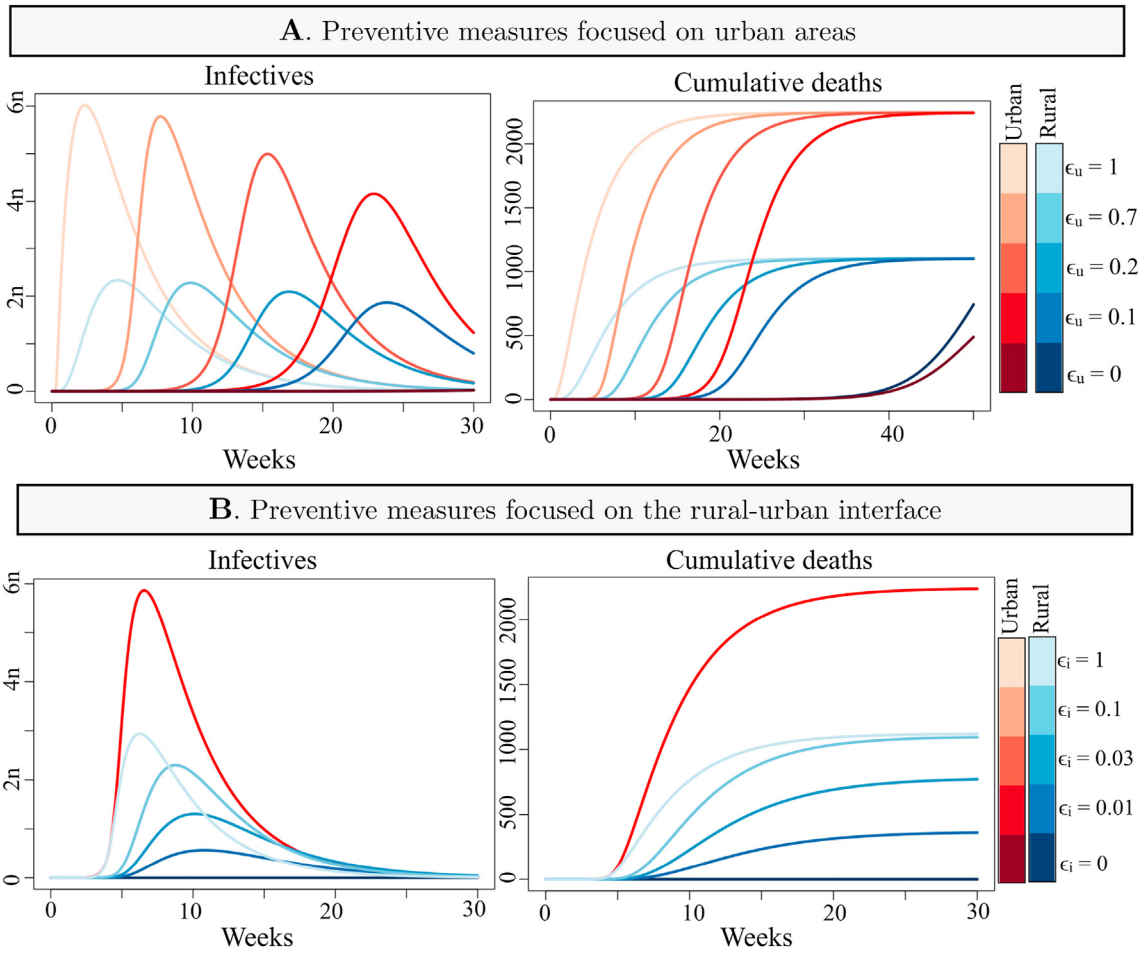

Fig. 1. Overall fraction infected (left) and death (right) individuals overtime for the rural (blue curve) and urban (red curves) structured community for five different preventive levels focused on A) urban areas and B) the urban-rural interface. The intensity of color corresponds to the intensity of the measures focused on the prevention of exposure and interaction in A) urban areas and B the urban-rural interface. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

urban-rural interface; for urban communities, the model can be written as

$$\begin{aligned}\dot{s}_u(t) &= -\varepsilon_u S_u(t) I_u(t) - \varepsilon_r S_u(t) I_r(t)\\ \dot{e}_u(t) &= \varepsilon_u S_u(t) I_u(t) + \varepsilon_r S_u(t) I_r(t) - \beta E_u(t)\\ \dot{i}_u(t) &= \beta E_u(t) - \gamma I_u(t) - \delta I_u(t) - \mu I_u(t)\\ \dot{d}_u(t) &= \delta I_u(t)\\ \dot{r}_u(t) &= \gamma I_u(t)\\ \dot{f}_u(t) &= \mu I_u(t)\end{aligned} \quad (1)$$

for rural communities, the model can be written as

$$\begin{aligned}\dot{s}_r(t) &= -\varepsilon_r S_r(t) I_u(t)\\ \dot{e}_r(t) &= \varepsilon_r S_r(t) I_u(t) - \beta E_r(t)\\ \dot{i}_r(t) &= \beta E_r(t) - \gamma I_r(t) - \delta I_r(t) - \mu I_r(t)\\ \dot{d}_r(t) &= \delta I_r(t)\\ \dot{r}_r(t) &= \gamma I_r(t)\\ \dot{f}_r(t) &= \mu I_r(t)\end{aligned} \quad (2)$$

where the initial number of susceptible individuals corresponds to all individuals who reside in rural or urban areas.

Results

Impact of control strategies focused on urban areas to contain SARS-CoV-2 in rural areas

In Fig. 1A, the community proportion that is infectious (left) and death (right) during the course of the epidemic in rural (blue) and urban (red) areas is plotted considering five different levels for the exposition rate in urban areas (ε_u) keeping intrarural and urban-rural exposition rates fixed. On week 0, preventive measures focused on urban population (at five different levels for ε_u) are put in place, and in every case, the preventive measures reduce the size and delay the time of the peak for the infectives (until 23 weeks when $\varepsilon_u = 0.1$; Fig. 1A, left), except when no preventative measures are applied (blue light and red light curves; $\varepsilon_u = 1$). For the urban infectives (Fig. 1A; left), the darkest curves ($\varepsilon = 0$) finish at $<99\%$ urban individuals getting infected or dead. When $\varepsilon = 0.1$ the urban infectives finish at $<18\%$ rural and $<4.5\%$ rural individuals getting infected. The corresponding cumulative fraction of deaths as a function of time is also shown in Fig. 1A (right), demonstrating that preventive measures focused on urban areas impact the number of deaths in urban areas (red curves). The number of deaths only changes in cases of extremes of low contact rate ($\varepsilon_u = 0$); however, in all cases, a delay in the peak is also observed. On the other hand, the response of infected individuals and cumulative deaths in rural areas (blue curves) upon changes in the dynamics is small but not negligible.

Impact of control strategies focused on the urban-rural interface to contain SARS-CoV-2 in rural areas

We then use the model to investigate the impact of control strategies focused on the urban-rural interface to contain the epidemic size of COVID-19 in rural areas. On week 0 (Fig. 1B), preventive measures (at five different levels for ε_i) are put in place, and in every case, the infectives and deaths are reduced in rural areas (blue curves) except when no preventive measures are applied (light blue curve; $\varepsilon_i = 1$). Moreover, the preventive measures reduce the size and delay the time of the peak in rural areas. For rural infectives (Fig. 1B; left), the darkest blue curve ($\varepsilon = 0$) finishes at $<100\%$ rural individuals getting infected, becoming clearer $\varepsilon = 0.01$ finishes at $<82.7\%$, $\varepsilon = 0.03$ finishes at $<55.2\%$, and $\varepsilon = 0.1$ finishes at $<24.1\%$ rural individuals getting infected. In urban areas (red curves), there is no obvious change. The corresponding cumulative fraction of deaths as a function of time is also shown in Fig. 1B (right). An interesting observation is that preventive measures focused on the urban-rural interface exclusively impact the number of deaths in rural areas (blue curves). For rural deaths (Fig. 1B; right), the darkest blue curve ($\varepsilon = 0$) finishes at $<100\%$ rural individuals dying, becoming clearer $\varepsilon = 0.01$ finishes at $<77.2\%$, $\varepsilon = 0.03$ finishes at $<36.3\%$, and $\varepsilon = 0.1$ finishes at $<4.5\%$ rural individuals dying. In urban areas (red curves), there is no either obvious change in deaths.

Discussion

In our model, we have taken social and work activity levels into account to avoid homogeneity. However, more complex infectious disease models have many other types of heterogeneities such as age,[8] place of residence,[9] or features associated with poverty in the region or country level.[10] Moreover, differences in social activity play a greater role in reducing the disease-induced herd immunity level than heterogeneous age-group mixing.[2]

When exploring the impact of control strategies focused on the urban-rural interface to contain the epidemic size of COVID-19 in rural areas, using the parameter ε_i, we indirectly consider the mobility of people between urban and rural areas and the transmission of the virus in this interface. Furthermore, SARS-CoV-2 transmission in urban areas depends primarily on the intraurban exposure rate (ε_u), since in high-contact environments such as urban regions, large households, overcrowded and poorly ventilated public transport, and large workplaces, there will be a higher infected fraction among highly active and connected individuals,[7] fundamental in the SARS-CoV-2 transmission.

When control measures focused on urban areas were investigated, the slope of the curves for rural infected individuals decreased (more than 10%) as the interaction between urban individuals decreases. This is probably because in this scenario the urban-rural interface, exposure rate is different to zero, which continues to guarantee the transmission of SARS-CoV-2 in rural areas.

In the explored scenarios, the intrarural exposure rate was close to zero due to the nature of lower contact rates in these regions.[2] In this way, from our findings, we can confirm that the dynamics of SARS-COV-2 in rural areas depend on the connectivity of these areas with urban areas.

In this work, we conclude that the maintenance of SARS-CoV-2 depends on the interaction of rural and urban individuals when marketing products and carrying out activities at the urban-rural interface. Thus, preventive measures focused on this interface reduce the size and delay the epidemic peak in rural areas. In this way, the restrictive measures established by the national government would not be required within rural areas.

These findings support public health decisions proposing the implementation of heterogeneous strategies focused on mitigating the health, economic, and social impact of the SARS-CoV-2 pandemic in rural communities.

Author statements

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Ethical approval

Not required. No human participants or their data were involved in this research.

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Competing interests

Authors declare no interests.

Data availability statement

Data supporting the findings of this study are freely available within the article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.02.007.

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Original Research

Trajectories of depression, anxiety and stress among adults during the COVID-19 pandemic in Southern Switzerland: the Corona Immunitas Ticino cohort study

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ABSTRACT

Objectives: Using longitudinal data from Southern Switzerland we assessed ten-month temporal trajectories of moderate to severe depression, anxiety and stress among adults after the first pandemic wave and explored differences between sociodemographic and health status groups.
Study design: This was a population-based prospective cohort study.
Methods: Participants were 732 (60% women) adults aged 20–64 years who completed the Depression, Anxiety and Stress Scale on a monthly base since August 2020 until May 2021, as part of the Corona Immunitas Ticino study based on a probability sample of non-institutionalized residents in Ticino, Southern Switzerland.
Results: Prevalence of moderate to severe depression increased from 7.5% in August 2020 to 12.5% in May 2021, anxiety increased from 4.8% to 8.1% and stress increased from 5.5% to 8.8%. A steeper increase in poor mental health was observed between October 2020 and February 2021. Men had a lower risk for anxiety (odds ratio [OR] = 0.58, 95% confidence interval [CI] = 0.36–0.95) and stress (OR = 0.61, 95% CI = 0.44–0.95) than women. Suffering from a chronic disease increased the risk for depression (OR = 1.82, 95% CI = 1.12–2.96), anxiety (OR = 2.38, 95% CI = 1.44–3.92) and stress (OR = 1.87, 95% CI = 1.14–3.08). The differences between these groups did not vary over time.
Conclusions: In a representative Swiss adult sample, prevalence of moderate to severe depression, anxiety and stress almost doubled in the course of ten months following the end of the first pandemic wave in spring 2020. Women and participants with pre-existing chronic conditions were at a higher risk of poor mental health.

Introduction

During the COVID-19 pandemic, the risk of psychological distress and mental disorders in the general population has increased.[1–3] Lockdown measures, prolonged financial hardship and exposure to and fear of potential infection are some of the contingent factors that continue to have detrimental effects on mental health.[4–6] However, changes in psychological distress levels may differ across different population groups and contexts.[2,7]

The World Happiness Report[8] outlines four phases to describe both short- and long-term negative impacts on mental health through the pandemic waves. The first two phases are mainly related to the introduction of lockdown measures and the broader socio-economic difficulties that followed. The subsequent phase entails the potential increase in demand for mental health services and the interplay between health and social services disruptions and exceeded capacity during and between the waves of the pandemic outbreaks. Finally, the population's mental health was and still is affected by the sustained exposure to socio-economic constraints, including abrupt changes to employment status,

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working conditions, income, schooling and social interactions, and the exacerbation of social inequalities. While the pandemic endures and with uncertainties about whether and when it will be over, empirical data of psychological distress and mental health changes over time and context-specific information are crucial to inform policy decision-making and guide community-level interventions.[9] However, epidemiological evidence from longitudinal population-based studies on trajectories and potential increases in psychological distress, depressive and anxiety symptoms in representative samples of the general population is generally sparse and lacking also from regions that have been markedly impacted during the first and second pandemic waves, including Southern Switzerland.

Population-based longitudinal studies in China,[10,11] the UK,[12–15] the Netherlands,[16] Spain,[17,18] Italy[19,20] and France[21] found high levels of depressive symptoms, anxiety and psychological distress among adults, in the months immediately after the first pandemic wave. Most studies focused simultaneously on multiple mental health symptoms, in particular depression and anxiety.[11,13,17,18,20] Measures of stress-related symptoms[10,16,19] and of overall measures of non-specific mental distress were less commonly ascertained.[12,14] Moreover, the majority of previous longitudinal studies relied on up to two or three data collection points.[22,23] Nevertheless, evidence of temporal variations and longitudinal patterns of mental health is limited,[24–27] particularly for the period during and after the second pandemic wave, when COVID-19 containment and mitigation control measures and restrictions endured and further contributed to the disruption of social life and caused far-reaching economic hardship.

The aim of this study was to assess ten-month repeated prevalence of moderate to severe depression, anxiety and stress among adults aged 20–64 years following the first pandemic wave in the Canton of Ticino (Switzerland), a region severely hit by the COVID-19 pandemic,[28] and to explore differences between sociodemographic and health status groups.

Methods

Study design and participants

We used data from the Corona Immunitas Ticino study in Southern Switzerland. Full details about sampling, recruitment and data collection procedures have been previously described.[29] Briefly, the Corona Immunitas Ticino study is a population-based, prospective cohort study purposely designed and conducted to assess the spread of the COVID-19 epidemic and its associated impact, including that on mental health, in Southern Switzerland. Participants are being followed up for repeated serological testing, self-reported symptoms and assessments, including mental and physical health, psychological well-being, risk of infection, adherence to infection prevention measures and lifestyle changes over time. The current study focused on adult participants (aged 20 to 64 years) who completed a baseline questionnaire in July 2020 providing sociodemographic and general health status information and who were prospectively followed up using repeated weekly and monthly digital assessments, since study inception. In July 2020, after the first wave of the epidemic, we sent invitation letters to 4000 adults aged 20 to 64 years living in Ticino drawn by the Swiss Federal Statistical Office to recruit a representative actual sample of the population in terms of age and gender distributions. During this phase, we recruited 1009 individuals (27% of those invited), who successfully completed the baseline assessments. In August 2020, 873 among these completed the first of 10 monthly follow-up assessments. All participants gave written informed consent to participate in the study.

Measurements and procedures

We collected data using secured online questionnaires implemented in the Research Electronic Data Capture (REDCap) software,[30] hosted at the Università della Svizzera Italiana. Sociodemographic and health status data included age, categorized into two age groups: (0) 20–49 and (1) 50–64 years; gender: (0) women, (1) men; education: (0) up to higher secondary/apprenticeship, (1) higher tertiary; obesity (0) as body mass index (BMI) < 30 kg/m^2, (1) BMI ≥30 kg/m^2; smoking status (0) non-smoker/former smoker, (1) current smoker (daily or occasional); and existing chronic conditions ("Do you suffer from any of the following chronic conditions?"): (0) none, (1) any among hypertension, diabetes, cardiovascular disease, cancer, immunological deficiency syndromes or respiratory syndromes.

We used the 21-item Depression, Anxiety and Stress Scale (DASS-21) to assess self-reported depressive symptoms, anxiety and stress levels at each monthly follow-up.[31] Each DASS-21 item is rated on a 4-level Likert scale, from 0 (never) to 3 (almost always). The DASS-21 was used in previous research on psychological distress associated with SARS[32] and COVID-19.[33] Each of the three DASS-21 scales contains 7 items, divided into subscales with similar content. Subscales' scores range from 0 to 21. We used standard cut-offs for moderate to severe levels of depressive symptoms (≥7), anxiety (≥5) and stress (>9) and computed a dichotomized score based on whether participants met or not case criteria for every DASS-21 dimension of distress. The DASS-21 showed good convergent, discriminant and nomological validity in normal samples[34,35] and good reliability between repeated assessments. Here, Cronbach's α ranged from 0.89 to 0.93 for depression, from 0.76 to 0.86 for anxiety and from 0.89 to 0.93 for stress across assessments.

Statistical analysis

We checked data quality (i.e., straight line scoring) and analyzed missing data patterns. We excluded responses due to straight line scoring on the DASS-21 items (<0.4% across assessments) and participants with DASS-21 missing values on more than 3 monthly assessments of 10 (Fig. S1 in the supplementary material; n = 141, 16.5%) and derived an analytic sample of 732. Next, we imputed missing values of repeated measures of depression, anxiety and stress (<11.3% across assessments) as a linear combination of available observations. We observed no significant differences in baseline mental health scores between participants excluded and included in the analytic sample. Missing values on education (n = 10, 1.4%), living alone (n = 4, 0.6%), obesity (n = 9, 1.2%) and chronic diseases (n = 2, 0.3%) were imputed as a function of age and gender. We then modelled moderate to severe depression, anxiety and stress as binary dependent variables in separate generalized estimation equation (GEE) models[36,37] to assess variance structure and clustering error within subjects. GEE models allow the determination of how the average of a subject's response changes with covariates while specifying variance structure for the correlation between repeated measurements in the same subject over time. To select the best-working covariance structure for the current data, we followed a model selection method described by Pan[38] and Cui:[39] smaller quasi-likelihood under the quasi-information criterion (QIC) values was indicative of better fit. We assessed three types of covariance structure:[40] exchangeable, assuming responses from the same cluster are equally correlated; autoregressive, where correlations between responses decrease across time; and unstructured, considering the correlations between responses to be comparatively complex. We tested GEE univariate models with

robust standard errors adjusted for age and gender. We then adjusted also for education, living alone, obesity, smoking and chronic diseases in multivariate models. We further tested significant between-subject effects in interaction with time and plotted results to ease interpretation. Statistical significance was considered for $P < 0.05$ for direct effects and $P < 0.1$ for interaction effects. We used Stata version 15, for all statistical analyses (StataCorp. 2015. Stata Statistical Software: Release 15. College Station, TX: StataCorp LP).

Results

Table 1 reports characteristics of the analytic sample. The analytic sample representativeness was fairly good. Age distributions by sex did not significantly differ between the study sample and the cantonal population demographics in 2019 although participation rate among those aged 20 to 30 years was smaller for both genders (Fig. S2).

Table 1
Characteristics of the sample at baseline, Corona Immunitas Ticino.

Variable	N (%)
N	732
Age, years, mean (SD)	46.84 (11.24)
Age group, years	
20–49	383 (52.3)
50–64	349 (47.7)
Woman	431 (59.9)
Educational level	
Up to higher secondary	479 (65.4)
Tertiary	253 (34.6)
Living alone	113 (15.4)
Obese (BMI ≥30 kg/m^2)	87 (11.9)
Smoking	164 (22.4)
Chronic diseases	134 (18.3)

Note. Chronic diseases include hypertension, diabetes, cardiovascular disease, cancer, immunological deficiency syndromes or respiratory syndromes.
BMI, body mass index; SD, standard deviation.

Fig. 1 presents GEE regression results with an exchangeable variance-covariance structure, which fitted the data better than an autoregressive or unstructured solution (see Table S1). The likelihood of depression ($\chi^2 = 31.89$, $P < 0.001$), anxiety ($\chi^2 = 22.60$, $P = 0.007$) and stress ($\chi^2 = 20.24$, $P = 0.017$) significantly increased over time: on average, every month participants experienced a 6% increase in the odds of falling into the moderate to severe classification for depression, anxiety and stress. Men had a lower risk for anxiety (odds ratio [OR] = 0.58, 95% confidence interval [95% CI] = 0.36, 0.95, $P = 0.029$) and stress (OR = 0.61, 95% CI = 0.44, 0.95, $P = 0.029$) than women. In addition, suffering from a chronic disease also increased the risk for depression (OR = 1.82, 95% CI = 1.12, 2.96, $P = 0.015$), anxiety (OR = 2.38, 95% CI = 1.44, 3.92, $P = 0.001$) and stress (OR = 1.87, 95% CI = 1.14, 3.08, $P = 0.014$) (Table S2). Fig. 2 shows 10-month longitudinal adjusted prevalence of moderate to severe depression, anxiety and stress, by gender and chronic diseases status. Overall, prevalence of moderate to severe depression increased from 7.5% (95% CI = 5.8%–9.1%) in August 2020 to 12.5% (95% CI = 10.1%–14.8%) in May 2021; moderate to severe anxiety increased from 4.8% (95% CI = 3.6%–6.1%) to 8.1% (95% CI = 6.3%–9.9%) and moderate to severe stress increased from 5.5% (95% CI = 4.2%–6.7%) to 8.8% (95% CI = 6.9%–10.8%). We found no significant interactions of gender or chronic diseases with time (expressed as continuous). While overall the differences observed at baseline remained stable over time, men and participants affected by at least one chronic disease had a higher prevalence of mental distress than women and participants with no chronic diseases, respectively. Increases in poor mental health were steeper

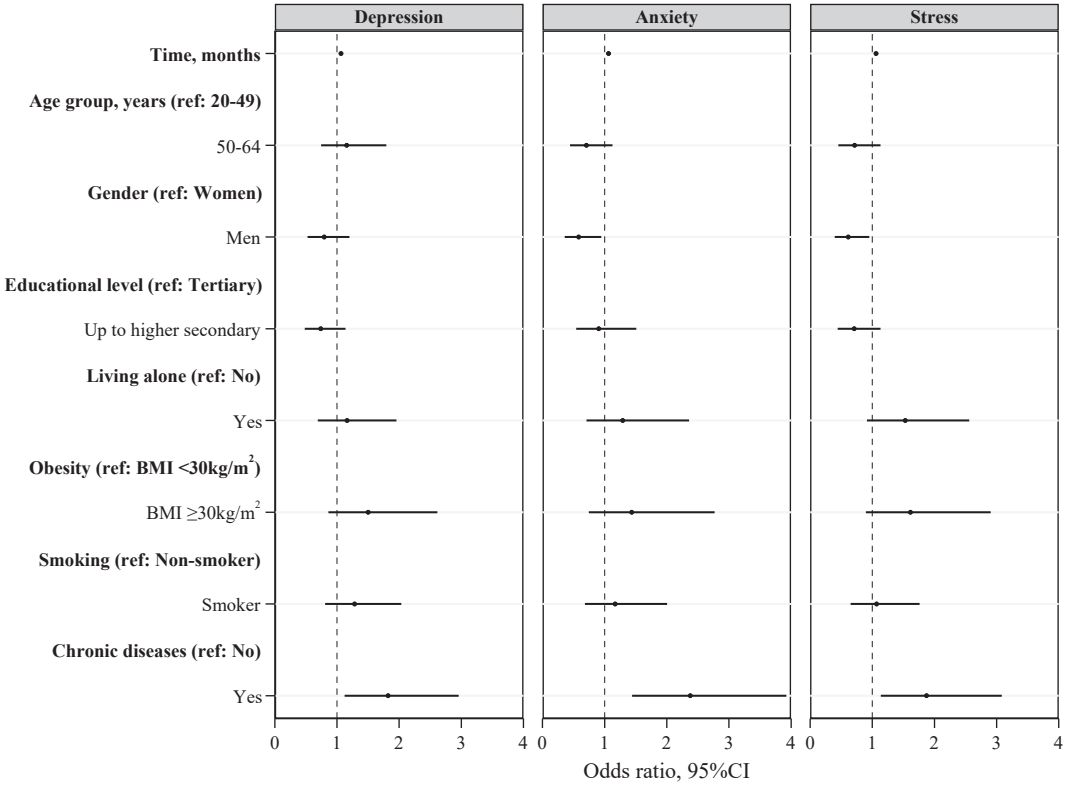

Fig. 1. Results of generalized estimating equation models explaining 10-month longitudinal prevalence of moderate to severe depression, anxiety and stress, Corona Immunitas Ticino (N = 732). Odds ratios with 95% confidence intervals (CIs) are from generalized estimating equation models with robust standard errors adjusted for all listed covariates. Chronic diseases include hypertension, diabetes, cardiovascular disease, cancer, immunological deficiency syndromes or respiratory syndromes. BMI, body mass index.

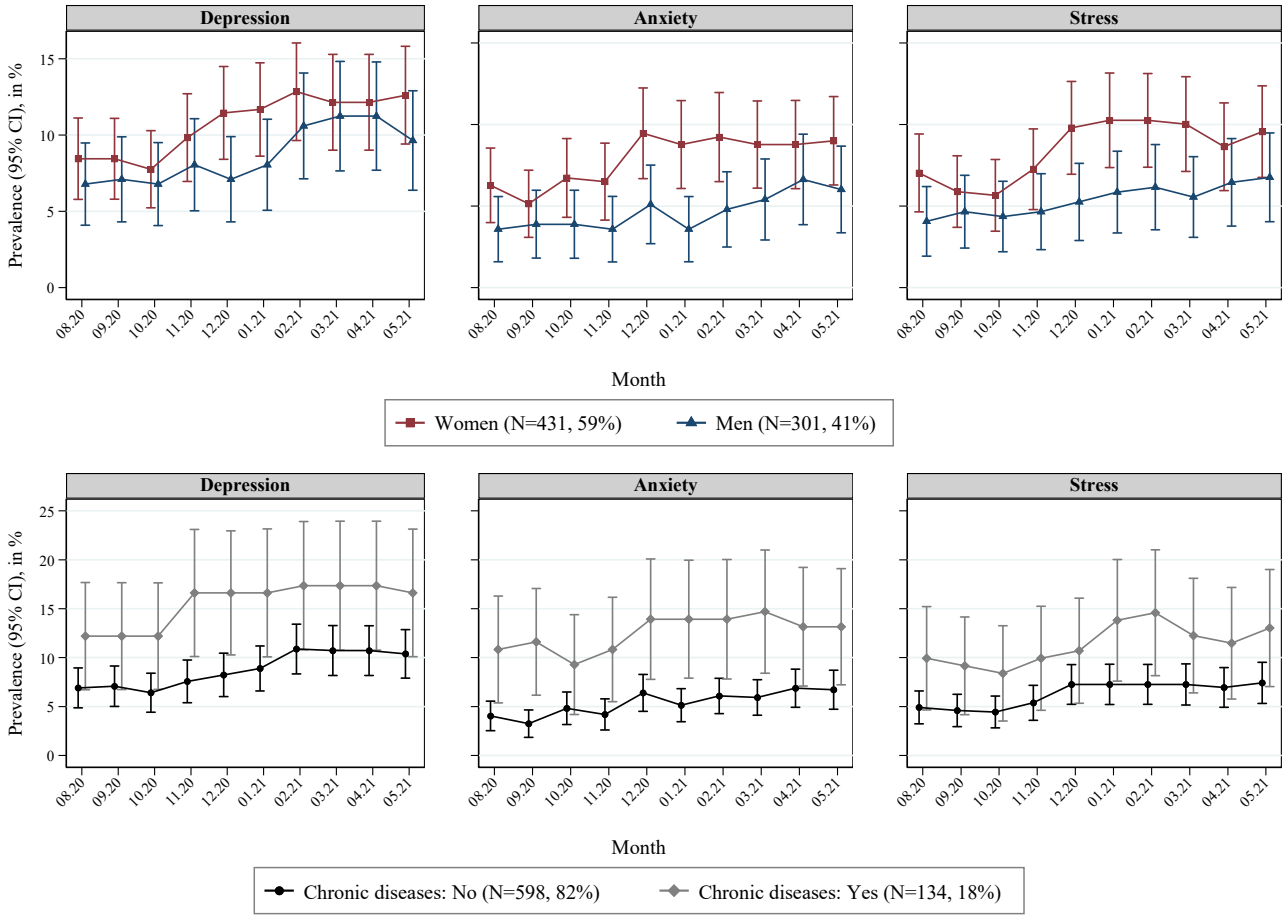

Fig. 2. Ten-month longitudinal adjusted prevalence of moderate to severe depression, anxiety and stress, by gender and chronic diseases status, Corona Immunitas Ticino. Prevalence estimates with 95% confidence intervals (CIs) are from generalized estimating equation models with robust standard errors adjusted for time (months), age, gender, education and living.

in winter, between October 2020 and February 2021, than the monthly increases in summer 2020 and spring 2021, in particular for moderate to severe depression and stress levels.

Results were unchanged in the set of sensitivity analysis of same GEE models ran in the restricted sample of participants without applying missing data imputations (N = 708), compared to the main results obtained in the larger analytic sample with missing data imputations (N = 732) Table S3.

Discussion

In a representative sample of adults living in Ticino, Southern Switzerland, we found that prevalence of moderate to severe depression, anxiety and stress almost doubled over ten months starting after the first COVID-19 pandemic wave in summer 2020. Moreover, psychological distress was consistently higher in women than in men and was associated with ill-health due to pre-existing chronic diseases. The pandemic is exacting a remarkable toll on the psychological well-being of the population. As the pandemic continues to unfold, our study highlights the importance of monitoring mental health in populations over time.

Our results are in line with those of studies on the mental health impact of the COVID-19 pandemic in specific subgroups of the population conducted in other Swiss regions and cantons, including in healthcare workers,[41] in young adults[42] and among hospital or clinic patients.[43] Moreover, our observations on the longitudinal trends in depressive, anxiety and stress symptoms among adults in Ticino do not differ from those reported in other studies conducted around the end of the first pandemic wave in late spring/early summer 2020. For example, Fancourt et al.[24] reported that depression and anxiety levels declined during summer 2020 among adults in the UK, following the end of the early lockdown restrictions. Similar results have been reported by Bendau et al.[44] in Germany. However, camparisons with previous studies are not straightforward due to differences in data collection periods and varying national pandemic conditions.[45,46]

The DASS-21 self-reported questionnaires have been used in several population-based studies, in China,[33,47] Iran,[48] Spain,[49] Austria[50] and Italy[51,52] and in large cross-national studies.[53,54] Overall, the DASS-21 subscales' scores reported in previous studies were generally higher than both the baseline and follow-up levels of psychological distress recorded over time in our sample. Whether this reflects prepandemic differences is not clear, and comparisons with previous studies is not straightforward also because epidemiological data based on the DASS-21 obtained from representative samples of the Swiss population are lacking. Nonetheless, our results are consistent with prepandemic levels in Switzerland of clinically significant depressive, anxiety and stress symptoms.[55–57]

We also found that women and participants suffering from pre-existing chronic conditions had higher DASS-21 scores of depression, anxiety and stress than men and healthy individuals, respectively. This is consistent with prepandemic research,[58,59] and with some[2,60,61] but not all research studies conducted during the pandemic period.[1,3] Women may be more exposed to the risk of

poor mental health because they may carry a heavier load in childcare provision than men,[62,63] which was highly affected by schools and childcare closures and home-based working during the lockdown and quarantine periods.[64] Our results confirm that COVID-19 had a disproportional impact on specific high-risk subgroups of the population including also individuals living with chronic diseases who may be more vulnerable to the negative effects of the pandemic on their physical and mental health because of poorer or reduced healthcare and treatment and higher perceived fear and uncertainty for their health in the event of a SARS-CoV-2 infection.[61,65,66] The impellent needed to increase capacity for patients with COVID-19 imposed a massive and abrupt reorganization of health system and services. Health services have been and, to some extent, still are discontinued, and their access, use and navigation have been greatly impacted.

Our findings are novel because we depicted psychological distress trajectories in a large and representative sample of the population using highly frequent repeated assessments and could monitor changes in psychological distress over time. For example, we found steeper increases of depressive symptoms and stress between October 2020 and February 2021. This period corresponds to the outbreak of the second wave of the pandemic in Europe, which lead to the tightening of previously partially relapsed restrictions to contain the pandemic. Our findings support the hypothesis that the timing and duration of restrictive measures likely play a relevant modulating effect on the mental health of the population.[51]

Strengths and limitations of the study

Our study has several strengths. First, this is the largest study carried out in Southern Switzerland in a representative sample from the general population during the COVID-19 pandemic period, with participants taking part in longitudinal follow-ups for a total of twelve months. Our study has strong external validity. In addition, we used validated and reliable assessment instruments to investigate several domains of mental health, which supports internal validity too. We conducted our analysis using ten monthly follow-up assessments, which allowed us to investigate the temporal variations and longitudinal patterns of mental health during an extended period of time through the COVID-19 pandemic.

Some limitations of our study must be noted. First, the baseline assessment started in August 2020; we lack data during the first lockdown period in spring 2020. However, our data suggest little differences in psychological distress during and right after the second lockdown in winter 2020–2021, which may reasonably apply also to the first wave of the pandemic that we did not capture entirely. Second, common to most studies in psychiatric epidemiology, we cannot exclude, nor can we appraise, the extent of selection bias. Participation and retention may be lower in people with more severe depressive symptoms than in those without mood-related symptoms because of lack of interest, anxiety and fatigue, all of which may impact willingness and, to same extent, ability to participate in longitudinal studies with highly intense, repeated, self-reported assessments. Our results may be an underestimate of the true prevalence of moderate to severe depression, anxiety and stress in the target population. Nonetheless, the opposite may be also possible because healthy people may have been busier and less interested in participating in a mental health survey, which they might have perceived as non-pertinent to them. Finally, the sample size did not allow us to investigate further socioeconomic and demographic differences in mental health with appropriate precision. This will be possible pooling data collected in the different study sites of the national Corona Immunitas collaborative initiative.[29]

Conclusions

This study showed that in a representative adult sample from a region in Switzerland that was severely hit by the COVID-19 pandemic, prevalence of moderate to severe depression, anxiety and stress almost doubled over ten months following the end of the first pandemic wave. However, despite this trend, psychological distress may not be worse than prepandemic and may in fact be less marked than in neighbouring countries in Europe. Women were at a higher risk of poor mental health, in addition to participants with pre-existing chronic conditions. These results have important implications for the adoption of future public health interventions to tackle the burden of mental disorders and to sensitize the general population and high-risk groups to the detrimental impact of the COVID-19 pandemic on mental health.

Author statements

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Ethical approval

The Corona Immunitas Ticino study was approved by the Ethics Committees of all the Swiss Cantons members of the projects (BASEC 2020-01247/BASEC 2020-01514).

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Competing interests

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.02.005.

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