Projecting the transition of COVID-19 burden towards the young population while vaccines are rolled out: a modelling study

Jun Cai\textsuperscript{1*}, Juan Yang\textsuperscript{1,2,3*}, Xiaowei Deng\textsuperscript{1}, Cheng Peng\textsuperscript{1}, Xinhua Chen\textsuperscript{1}, Qianhui Wu\textsuperscript{1}, Hengcong Liu\textsuperscript{1}, Juanjuan Zhang\textsuperscript{1,2,3}, Wen Zheng\textsuperscript{1}, Junyi Zou\textsuperscript{1}, Zeyao Zhao\textsuperscript{1}, Marco Ajelli\textsuperscript{4,5†}, Hongjie Yu\textsuperscript{1,2,3†}

1. Department of Infectious Diseases, Huashan Hospital, School of Public Health, Fudan University
2. Key Laboratory of Public Health Safety, Ministry of Education, Shanghai, China
3. Shanghai Institute of Infectious Disease and Biosecurity, Fudan University, Shanghai, China
4. Department of Epidemiology and Biostatistics, Indiana University School of Public Health, Bloomington, IN, USA
5. Laboratory for the Modelling of Biological and Socio-technical Systems, Northeastern University, Boston, MA, USA

*These authors contributed equally to this work.
†These authors are joint senior authors contributed equally to this work.

Corresponding authors: Hongjie Yu, Shanghai Institute of Infectious Disease and Biosecurity, School of Public Health, Fudan University, Shanghai 200032, China
E-mail: yhj@fudan.edu.cn

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Abstract

SARS-CoV-2 infection causes most cases of severe illness and fatality in older age groups. In China, over 85% of individuals aged ≥12 years have been vaccinated against COVID-19 (albeit with vaccines developed against historical lineages), while children aged 0–11 years are currently not eligible for vaccination (as of September 2021). The aim of this work is to assess whether the importation of Delta variant infections will shift the COVID-19 burden from adults to children. We developed an age-structured susceptible-infectious-removed model of SARS-CoV-2 transmission dynamics to simulate the epidemics triggered by the importation of Delta variant infections and project the age-specific incidence of SARS-CoV-2 infections, cases, hospitalisations, intensive care unit (ICU) admissions, and deaths. In the context of the vaccination programme targeting individuals aged ≥12 years (as of September 2021), and in the absence of non-pharmaceutical interventions, the importation of Delta variant infections could lead to widespread transmission and substantial disease burden in mainland China, even with vaccination coverage as high as 97% across the currently eligible age groups. The symptomatic SARS-CoV-2 infections and hospitalisation are projected to shift towards children and young adolescents, with 13% of symptomatic infections and 30% of hospitalisations occurring in those aged 0–11 years. Extending the vaccination roll-out to include children aged 3–11 years is estimated to dramatically decrease the burden of symptomatic infections and hospitalisations within this age group (54% and 81%, respectively), but would have a low impact on protecting infants (aged 0–2 years). Our findings highlight the need to strengthen vaccination efforts by simultaneously extending the target population and elevating vaccine effectiveness.
Older age groups have the highest risk of severe illness and fatality from SARS-CoV-2 infection. While the vaccination coverage in China is highly skewed towards older age groups. No study has quantified to what extent the spread of Delta variant infections and lack of vaccination in younger age groups will shift the COVID-19 burden towards younger age groups and how this will affect the return to normal. To this end, we developed an age-structured transmission model to mimic the epidemics triggered by imported Delta variant infections in China. In the context of the vaccination programme targeting individuals aged ≥12 years as of September 2021, and in the absence of non-pharmaceutical interventions, the importation of Delta variant infections would lead to substantial disease burden, which will shift towards the 0–11-year age group. Extending the vaccination to children aged 3–11 years, for whom the currently available vaccines have been licensed, is projected to dramatically decrease symptomatic infections and hospitalisations within this age group but would have a low impact in protecting infants aged 0–2 years. This study highlights the value of extending vaccination to children aged 3–11 years and protecting infants 0–2 years by vaccinating their contacts.
Introduction

The coronavirus disease 2019 (COVID-19) pandemic is still raging worldwide. The highly contagious Delta variant (B.1.617.2) of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has become the dominant strain across the world\cite{1,2}. The global circulation of the Delta variant has led to a resurgence of COVID-19 cases worldwide, including in areas with high vaccination coverage\cite{3,4}.

A clear positive correlation has been shown between severe illness and fatality from SARS-CoV-2 infection and increasing age\cite{5-7}. COVID-19 vaccines are highly efficacious in preventing severe illness\cite{8-10}. Due to the age-prioritised vaccination strategies adopted by most countries\cite{11}, vaccine coverage tends to be higher in older adults\cite{12}. However, since the summer of 2021, while the Delta variant continued its spread, the number of COVID-19 cases and hospitalisations have trended upwards in many countries with an increasing fraction of children and adolescents\cite{13-16}.

China has been able to avoid the widespread local transmission of SARS-CoV-2 since March 2020\cite{17}. However, the importations of Delta variant infections have caused several local outbreaks, the largest of which occurred in Nanjing city and led to over 1,000 reported cases and spilled over to >25 cities\cite{18}. The most recent outbreak started in September 2021 in Putian City, where it spread to a second location, Xiamen City, and caused local transmission. Similar to what was observed in other countries, this outbreak is characterized by a high proportion (57/129) of notified infections in children younger than 12 years\cite{19}.

To prevent the spread of infection in younger age groups, in late July 2021, China extended the vaccination programme to include adolescents (aged 12–17 years). As of September 15, 2021, 1.99 billion and 0.17 billion doses were administered to adults (18+ years) and adolescents (12–17 years), respectively, corresponding to 92% and 88% of these two target populations\cite{20}. Two inactivated COVID-19 vaccines have
already obtained emergency use approval for administration in individuals aged ≥3 years. The vaccination roll-out is expected to include children aged 3–11 years at a later stage[21]. No vaccine has yet received approval for use in children aged ≤2 years.

The vaccines used in mainland China were developed using historical SARS-CoV-2 lineages and have proven to be highly effective in protecting against severe illness caused by the Delta variant[22-24]. However, their effectiveness in preventing infection appears to be reduced[25]. Moreover, vaccination coverage is highly skewed towards older age groups. It is thus legit to ask whether the spread of Delta variant infections and lack of vaccination in younger age groups will shift the COVID-19 burden towards younger age groups and how this can affect the return to normal. To fill this gap, we developed an age-structured SARS-CoV-2 transmission model to project age-specific epidemiological outcomes, should an epidemic start to unfold. In particular, the model is used to forward simulate alternative vaccination strategies and allows tracking the number of infections, cases, hospitalisations, intensive care unit (ICU) admissions, and deaths by age.

Methods and methods

SARS-CoV-2 transmission and vaccination model

We developed an age-structured (16 age groups, Table S2) stochastic compartmental susceptible-infectious-removed (SIR) model to simulate the transmission of SARS-CoV-2 (Delta variant) and assess the health impact of age-targeted vaccination campaigns (Fig S1). Detailed information about the model and adopted parameters are described in S1 Text. A summary is presented here.

The model is calibrated to represent the Chinese population and considers the age-mixing patterns quantified prior to the COVID-19 pandemic[26]. Based on contact tracing data in the Hunan province of China[27], children aged under 15 years were
found to have a lower susceptibility to SARS-CoV-2 infection than other age groups, which was confirmed by several independent studies \[28\] (Table S1). A sensitivity analysis considering homogeneous susceptibility across age groups is presented in Fig S3. Simulations were initiated with 40 imported infections \[29\] on November 1, 2021 and run forward for 1 year. We considered a basic reproductive number \(R_0 = 6\) for the Delta variant \[30-32\]. It is still unclear whether the Delta variant has a shorter generation time than the original lineage, but a first analysis conducted in Singapore found no significant difference \[33\], and as such, we set the average generation time of the Delta variant to be 7 days, in line with estimates for the wild type \[34\].

**Vaccination strategy and vaccine effectiveness**

We considered two vaccination strategies: (1) vaccination of individuals aged \(\geq 12\) years (here referred to as the "adults+adolescents" vaccination strategy), in agreement with the vaccination programme in place in China as of September 2021; (2) as in strategy (1), but the target population is extended to include children aged 3–11 years starting from November 1, 2021—this strategy is referred to here as the "adults+adolescents+children" vaccination strategy. We consider that susceptible individuals are only eligible for vaccination, mimicking the programme implemented in China. Moreover, we accounted for individuals with contraindications against vaccination and pregnant women as they were excluded from the Chinese vaccination programme (Table S2) \[35\]. We simulated the daily distribution of vaccine doses according to the observed vaccination capacity (S1 Text).

We considered a two-dose vaccine with a 21-day interval between doses. Fourteen days after the second dose, the vaccine efficacy in protecting against an infection caused by the Delta variant was set at 54.3% \[35\]. The considered vaccine effectiveness (VE) against clinical endpoints such as symptomatic COVID-19, hospitalisations, ICU admissions, and deaths are reported in Table 1. We further explored a range of higher VE values for the sensitivity analyses (Fig S7). We considered VE to be homogeneous across age groups \[36-38\]. We considered a
“leaky” vaccine in which all vaccinated individuals are exposed to a lower risk of infection, which is 1-VE times that of non-vaccinated individuals[39]. We assumed that both the vaccine and natural infection confer protection for longer than the study period (i.e., 1 year)[40].

Model of COVID-19 burden
The number of infections was produced by the transmission model previously described. To estimate the COVID-19 burden, we rescaled the number of infections to obtain estimates of the cumulative incidence of symptomatic cases, hospitalisations, ICU admissions, and deaths under different vaccination strategies (S1 Text).

Integrating different studies in Scotland[41], Canada[42], and England[43, 44], we estimated that the increased risk associated with the Delta variant was 182% (97–317%) for hospitalisation, 287% (98–399%) for ICU admission, and 137% (50–230%) for death compared to the original lineage, respectively (Table 1). We also assumed that the age-specific probability of developing symptoms upon Delta infection is similar to that of the historical lineage. This choice was inspired by the finding that no significant difference was found for the Alpha variant as compared to historical lineages[45]. To compare the severity of disease across different age groups, we calculated the rate ratios as the incidence rate per age group dividing the overall incidence rate for each health outcome under different vaccination strategies.

Data analysis
For each scenario, 200 stochastic simulations were performed. The outcomes of these simulations determined the distribution of the cumulative number of symptomatic infections, hospitalisations, ICU admissions, and deaths by age. We defined 95% credible intervals as quantiles of the estimated distributions of 0.025 and 0.975.
Table 1. Parameters regulating the transmissibility, vaccine effectiveness/efficacy, and COVID-19 burden

| Parameter description | Estimated value for the SARS-CoV-2 Delta variant |
|-----------------------|--------------------------------------------------|
| **Epidemiology**      |                                                  |
| Basic reproduction number ($R_0$) | 6[30-32]                                         |
| **Vaccine effectiveness/efficacy** |                                                 |
| Against infection (%) ($\epsilon$) | 54.3[35]                                         |
| Against symptomatic disease (%) ($\epsilon_{sym}$) | 69.5 (42.8, 96.3)[22]                           |
| Against hospitalisations (%) ($\epsilon_{hosp}$) | 87.5 (86.7, 88.2)[8] *                          |
| Against ICU admissions (%) ($\epsilon_{icu}$) | 93[22-24] b                                     |
| Against deaths (%) ($\epsilon_{death}$) | 93[22-24]                                         |
| **Disease burden c**  |                                                  |
| Proportion of infections that develop symptoms for the wild-type ($r_a^{symp}$) | 18.1%, 22.4%, 30.5%, 35.5%, and 64.6% for 0–19, 20–39, 40–59, 60–79, and ≥80 years[7] |
| Proportion of infections that require hospitalisation for the wild-type ($r_a^{hosp}$) | 7.24%, 6.54%, 10.16%, 12.00%, and 21.83% separately for 0–19, 20–39, 40–59, 60–79, and ≥80 years[6, 7] |
| Proportion of infections that require ICU for the wild-type ($r_a^{icu}$) | 0.1014%, 0.2747%, 0.4266%, 0.7617%, 0.8999%, 2.8198%, and 5.1312% separately for 0–19, 20–39, 40–49, 50–59, 60–64, 65–79, and ≥80 years[6, 7, 46] |
| Infection fatality ratio for the wild-type ($r_a^{death}$) | 0.0923%, 0.1456%, 0.7259%, 3.7346%, and 6.7959% separately for 0–19, 20–39, 40–59, 60–79, and ≥80 years[6, 7] |
| Risk ratio of symptomatic infection associated with the Delta variant compared to the wild-type ($\Delta_{WT-Delta}^{symp}$) | 1[45] *                                     |
| Risk ratio of hospitalisation associated with the Delta variant compared to the wild-type ($\Delta_{WT-Delta}^{hosp}$) | 2.82 (1.97, 4.17)[41-44] |
| Risk ratio of ICU admission associated with the Delta variant compared to the wild-type ($\Delta_{WT-Delta}^{icu}$) | 3.87 (1.98, 4.99)[42] |
| Risk ratio of death associated with the Delta variant compared to the wild-type ($\Delta_{WT-Delta}^{death}$) | 2.37 (1.50, 3.30)[42] |

* Although the main variants of concern detected in Chile during the study period from February 2 to May 1, 2021 were the Alpha and Gamma variants, we assumed that the effectiveness reported in reference [8] applies to the Delta variant.

b Pooling the effectiveness of inactivated COVID-19 vaccines against severe illness caused by the Delta variant estimated in the recent outbreaks of the Delta variant in Guangdong[22, 23] and Jiangsu[24], China, we assume conservative effectiveness in preventing serious illness.

c The risks of different clinical outcomes associated with the Delta variant are expressed as increased risks compared to the wild-type.

d Based on the conclusion that no significant change in reported symptoms associated with the Alpha variant compared to wild-type is found in reference[45], we assumed that the probability of developing symptoms by age for the Delta variant is the same as the wild-type.
Results

Baseline scenario

In the baseline scenario, we assumed that 40 individuals infected with the Delta variant were introduced in the population on November 1, 2021, and the basic reproduction number $R_0$ was 6 in the absence of interventions and immunity[30-32]. Given the actual vaccination rates, we project that the "adults+adolescents" vaccination strategy could reach a 97% coverage of the target population (83% of the total population) by November 1, 2021 (Fig 1A).

Model simulations suggest that the importation of Delta variant infections in November 2021 would still have the potential to generate a major epidemic wave in the absence of non-pharmaceutical interventions (NPIs). Such an epidemic is estimated to cause 1,693 (95% CI, 1,596–1,738) symptomatic infections, 750 (95% CI, 686–776) hospitalisations, 48 (95% CI, 45–50) ICU admissions, and 38 (95% CI, 35–40) deaths per 10,000 individuals over 1 year (Figs 1C and 2). These figures correspond to 11–21 fold the disease burden of the initial epidemic in Wuhan, China[6]. Under the adopted vaccination programme, 13% of symptomatic infections and 30% of hospitalisations were estimated to occur in children younger than 12 years (Fig S6), who are ineligible for COVID-19 vaccination as of September 2021.

Two inactivated COVID-19 vaccines have been licensed for use in children aged 3–17 years[47, 48]. However, vaccination has not been implemented among children aged 3–11 years as of September 2021. Here, we simulate a scenario where the vaccine is offered to children aged 3–11 years (representing 11.0% of the population) from November 1, 2021 (i.e., the "adults+adolescents+children" vaccination strategy). As compared to the "adults+adolescents" vaccination strategy, this alternative strategy is estimated to reduce the incidence of symptomatic cases, hospitalisations, ICU admissions, and deaths by 6% (95% CI, 3–12%), 20% (95% CI, 17–27%), 8% (95% CI, 4–15%), and 5% (95% CI, 1–13%), respectively (Fig 2). Despite the beneficial
mitigation effect of this strategy, extending vaccination to children is estimated not to be enough to suppress viral circulation. Indeed, 5.2 million deaths (95% CI, 4.8–5.4) (approximately 0.3% of the Chinese population) are projected under this vaccination programme, should NPIs not be implemented (Fig S6).

We used the model to simulate a counterfactual scenario to estimate what would have happened if a vaccination programme had not been implemented. Compared with this scenario, the "adults+adolescents" vaccination strategy led to a 47% and 54% increase in the rate ratios of symptomatic infections in children aged 0–2 and 3–11 years, respectively. We recall that the rate ratio is defined as the incidence rate per age group divided by the overall incidence rate[49]. A higher increase is observed in the rate ratios of hospitalisation for these two population groups: 178% and 191% for children aged 0–2 and 3–11 years, respectively. At the same time, the rate ratios in adults aged ≥60 years is estimated to decrease by 25%. Similar patterns are observed in the rate ratios of ICU admissions and deaths (Fig 3). Extending the vaccination to children aged 3–11 years is projected to dramatically decrease the burden of symptomatic infections and hospitalisations within the same age group by 54% and 81%, respectively (Fig S6). However, due to the strong age-assortativity of contact patterns of this age group (i.e., individuals aged 3–11 years primarily mix with other individuals of the same age) (Fig S4A), extending the vaccination to children does not strongly impact the COVID-19 burden in other age groups (Fig S6). No evident effect is projected on the 0–2-year age group (Fig 3 and S6).

Under either the "adults+adolescents" or "adults+adolescents+children" vaccination strategies, the mean incidence of symptomatic cases among unvaccinated individuals is estimated to be 1.5–2.0 fold that of vaccinated individuals, with larger differences observed in terms of the incidence of severe clinical outcomes (3.4–5.0 fold for hospitalisation, 5.5–8.8 fold for ICU admission, and 4.1–8.8 fold for death) (Fig 2).

Improving VE, in the absence/presence of NPIs
In our model, VE in preventing ICU admissions and deaths caused by a Delta variant infection was set at 93%, based on real-world VE studies in Guangdong and Jiangsu, China (Table 1)[22-24]. Should the VE against the infection of the Delta variant be increased to >84% from 54.3% used in the baseline[35], the "adults+adolescents+children" vaccination strategy is estimated to reduce the number of deaths by 99% even in the absence of any NPIs, leading to <40,000 deaths over 1 year, similar to the annual excess respiratory disease deaths associated with influenza in China[50] (Fig S7).

We leveraged the developed model to explore the impact of implementing different levels of NPIs on the COVID-19 burden while the "adults+adolescents+children" vaccination strategy is in place and considering different levels of VE against infection. When VE against infection is set at 54.3% (baseline scenario), stringent NPIs capable of maintaining the net reproduction number $R_e < 2.5$ are needed, in combination with the vaccination programme, to reduce the yearly COVID-19 death toll to a level similar to that of seasonal influenza[50] (<50,000 deaths). Should a new vaccine with higher (>75%) VE against the infection be adopted, NPIs could be relaxed. Moderate NPIs able to keep $R_e < 4.3$ in combination with the vaccination programme is estimated to be sufficient to decrease the annual number of deaths to less than 40,000 (Fig S7).

**Sensitivity analysis on susceptibility to infection and contact patterns by age**

In the baseline analysis, age-varying susceptibility to SARS-CoV-2 infection was considered. That is, using adults aged 15–64 years as a reference group, children have a 42% lower risk of infection than adults (Table S1)[27]. No estimates are available for susceptibility to Delta variant infections by age. As such, we performed an analysis assuming the same susceptibility to infection across all age groups. The obtained results are consistent with those obtained in the baseline analysis, with average variations lower than 12% (Fig S3).
Another feature able to shape the epidemiology of COVID-19 is the contact pattern of the population. In the baseline analysis, we used pre-pandemic mixing patterns to represent a situation close to the objective of returning to a pre-COVID-19 pandemic lifestyle[26] (Fig S4A). However, whether mixing patterns will ever return to be the same after the pandemic remains to be seen. As such, we tested the robustness of our findings by considering an alternative contact matrix estimated in Shanghai, China, right after the end of the lockdown in March 2020[51] (Fig S4B). The obtained results are consistent with those obtained with the pre-pandemic contact matrix, with mean variations in the estimated burden lower than 6% (Fig S5).

Discussion

Our modelling study indicates that, under a vaccination programme targeting individuals aged ≥12 years, symptomatic SARS-CoV-2 infections and hospitalisation would shift towards children and young adolescents in the case of a new COVID-19 wave caused by the Delta variant. These modelling results obtained for China are backed up by empirical evidence from other countries, where an upsurge of COVID-19 cases and hospitalisations among children and adolescents has been reported since the summer of 2021[13, 14, 49]. Evidence of this epidemiological shift towards children and adolescents comes from the analyses of local outbreaks in Putian city, China, in September 2021, where 44.2% of the reported cases occurred in those aged 0–11 years[19].

The numbers depicted by the model are related to the relatively low vaccine efficacy of the vaccines in use in China against Delta variant infection (54.3%[35]) as of September 2021. Model projections show that, in the absence of NPIs, even when 97% of the population aged ≥12 years is fully vaccinated, the importation of Delta variant infections could lead to a new COVID-19 wave and substantial health burden. In particular, the estimated number of deaths over 1 year was 38 per 10,000 individuals as compared, for instance, with 3.6 deaths per 10,000 individuals in the
first epidemic wave in Wuhan in early 2020[6]. Extending vaccination to children would mitigate the number of symptomatic cases and severe outcomes but would not be enough to suppress transmission. Relying on NPIs such as border control screenings, border quarantine, isolation, and mask wearing remains key in this phase of widespread circulation of highly transmissible SARS-CoV-2 variants across the globe. This finding is consistent with studies in France, the UK, and the US where, despite the distribution of more effective vaccines (e.g., mRNA vaccines and adenoviral vector vaccines), the transmission is far from being suppressed as of September 2021[52-54].

To return to normal (i.e., no NPIs), the combination of high vaccine coverage, including children and adolescents, and a highly efficacious vaccine that prevents infection appear to be key to reducing COVID-19 burden to levels closer to those of seasonal influenza. To reach this target, our modelling results suggest that the vaccination programme would need to be extended to children aged 3–11 years, and vaccine efficacy against the infection would need to be >84%, in line with the efficacy estimated for the mRNA-1273 (Moderna) vaccine[9]. China is currently attempting to develop mRNA vaccines[55], vaccines that specifically target the Delta variant[56], multi-valent vaccines, and universal vaccines[57-59]. However, whether such vaccines will become available in the short term is unknown. Moreover, the waning of vaccine-induced immunity may also worsen the situation[54, 60-62]. For this reason, several countries recommend booster shots, at least for certain high-risk groups[63, 64]. The debate on whether to prioritise the administration of booster doses to older age groups or extend the vaccination programme to those aged 3–11 years merits further modelling investigations. Currently, the best way to protect infants (aged 0–2 years) appears to be by vaccinating their contacts, such as family members.

Although the inactivated vaccines in use in China as of September 2021 show a relatively low effectiveness against mild and moderate disease caused by Delta variant infection, they appear to be highly effective against severe outcomes[8, 22, 23]. In the
context of a constantly changing virus and the evolving epidemiology of the
pandemic, it is of great importance to continue to ramp up efforts to increase
vaccination coverage by using currently available vaccines. Promoting equitable
access to COVID-19 vaccines is critical to decreasing viral circulation and the
likelihood of the emergence of new variants of concern.

Our findings should be interpreted by considering the following limitations. First, we
assumed that vaccine protection lasted longer than the time of our simulations (1
year). Recent immunological studies have shown that the neutralising antibody titres
of inactivated vaccines decline to a low level at 6 months after the second vaccine
dose[60, 61], which may indicate waning of vaccine efficacy. However, the
correlation with protection from SARS-CoV-2 infection has yet to be proven. Second,
we estimated the disease burden potentially caused by the importation of Delta variant
infections in the absence or presence of NPIs. The impact of NPIs has been modelled
through a simple reduction in transmissibility occurring homogenously with age. We
still lack evidence regarding whether this is the case or whether NPIs lead to age-
related effects. Moreover, our analysis is not suited to pinpoint which NPIs need to be
performed to reach the considered levels of transmission reduction. Further studies
exploring this direction are required.

In conclusion, in the absence of NPIs, the importation of Delta variant infections
could lead to widespread transmission and substantial disease burden in mainland
China, even with vaccination coverage as high as 97% of those aged ≥12 years. Our
findings highlight the need to strengthen vaccination efforts by simultaneously
extending the target age groups of the vaccination campaign, and elevating VE via
booster vaccination and developing new highly efficacious vaccines. Although
vaccination is key to dramatically reducing severe outcomes of SARS-CoV-2
infections and the overall burden of the COVID-19 pandemic, vaccination
programmes targeting individuals aged ≥12 years can potentially shift the COVID-19
burden towards younger ages. This highlights the importance of extending
vaccination to children aged 3–11 years and protecting infants by vaccinating their contacts.
Supporting information

S1 Supporting information. Extended details on methods and additional analyses.

Author Contributions

Conceptualization: Hongjie Yu.

Data curation: Jun Cai, Juan Yang, Xiaowei Deng, Xinhua Chen, Qianhui Wu, Hengcong Liu, Juanjuan Zhang, Wen Zheng, Junyi Zou, Zeyao Zhao.

Formal analysis: Jun Cai, Juan Yang, Xiaowei Deng, Cheng Peng.

Funding acquisition: Hongjie Yu.

Investigation: Jun Cai, Juan Yang, Xiaowei Deng, Peng Cheng, Marco Ajelli, Hongjie Yu.

Methodology: Jun Cai, Xiaowei Deng.

Software: Jun Cai, Xiaowei Deng.

Supervision: Hongjie Yu.

Validation: Jun Cai, Xiaowei Deng, Hengcong Liu.

Visualization: Jun Cai, Xiaowei Deng, Cheng Peng, Juan Yang.

Writing-original draft: Jun Cai, Juan Yang.

Writing-review & editing: Marco Ajelli, Hongjie Yu.

Competing interests

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Data Availability Statement

The data and code that support the findings of this study will be made available on
GitHub upon the acceptance of this manuscript.

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Figures

Fig 1. Time series of vaccine coverage and daily incidence of new SARS-CoV-2 Delta variant infections. A Age-specific vaccine coverage over time for the "adults+adolescents" vaccination strategy. The vaccination programme was initiated on November 30, 2020 (as first officially reported in China). The vertical dotted lines represent the (simulated) seeding of the infection (November 1, 2021). The subpanel reports a table showing the age-specific coverage. The line corresponds to the mean value, while the shaded area represents the 95% quantile intervals (CI). B As A, but for the "adults+adolescents+children" vaccination strategy. C Simulated daily incidence of new SARS-CoV-2 Delta variant infections per 10,000 individuals for the two strategies (mean and 95% CI).
**Fig 2. Disease burden due to an epidemic caused by the introduction of SARS-CoV-2 Delta variant infections in China.**

**A** Cumulative number of symptomatic cases per 10,000 individuals after one simulated year by vaccination strategy (AA = "adults+adolescents" vaccination strategy, AAC = "adults+adolescents+children" vaccination strategy), vaccination status, and age group. The vaccinated group are those individuals who are administrated with two doses. **B** As A, but for the incidence of hospitalisations. **C** As A, but for the incidence of ICU admissions. **D** As A, but for mortality. The horizontal dotted lines in **A, B, and D** represent the rates of symptomatic cases, hospitalisations, and deaths, respectively, of the first pandemic wave of COVID-19 in Wuhan, China[6].
Fig 3. Rate ratios of symptomatic cases, hospitalisations, ICU admissions, and deaths due to SARS-CoV-2 Delta variant infections in China by age group and vaccination strategy. NV = no vaccination, AA = "adults+adolescents" vaccination strategy, AAC = "adults+adolescents+children" vaccination strategy.
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