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Impact of tiered measures on social contact and mixing patterns of adults in Italy during the second wave of COVID-19

Keywords: COVID-19, contact matrices, non-pharmaceutical interventions, social contact patterns, disease outbreak

Extended Abstract

The COVID-19 pandemic has significantly affected social contact patterns around the world. Due to the lack of specific treatments or vaccines, most countries around the world enforced non-pharmaceutical interventions. Italy was one of the first countries to be strongly affected by the pandemic, imposing a hard lockdown, in the first epidemic wave. During the second wave, the country implemented progressively restrictive tiers at the regional level. In particular, a four color-coded "zones" system (i.e., lower to higher severity: white, yellow, orange, and red) was introduced according to the weekly epidemiological risk assessments, i.e. incidence of the disease, the occupation rate of COVID-19 dedicated beds in the hospitals, and the occupation rate of beds in intensive care. The following work quantifies the impact of these restrictions on contacts and on the reproduction number. Representative (with respect to age, sex, and region of residence) longitudinal surveys of Italian adults were undertaken during the second epidemic wave (December 2020 - April 2021) by the CoMix initiative [1]. Epidemiologically relevant contact patterns were measured and compared with pre-pandemic levels and according to the level of interventions experienced by the participants. The pre-pandemic baseline was defined by the POLYMOD dataset for Italy [2]. Based on the information reported in the surveys, age-stratified contact matrices for adults ranging from 18 to 60 years and older were calculated. Contact matrix elements were computed according to the following equation:

$$m_{ij} = \frac{\sum_{t=1}^{T_i} w_{it} y_{ijt}}{\sum_{t=1}^{T_i} w_{it}}$$

where y_{ijt} denotes the reported number of contacts experienced by participant t of age i with someone of age j. T_i denotes all participants of age i, and w_{it} is the post-stratification weight. Contact matrices were then used to quantify the reduction in the number of contacts by age group and contact setting, Fig.1. Notably, while during the pre-pandemic period, most contacts happened between the same age classes (thus confirming the assortative mixing of individuals [2]), this is not entirely true for the contact matrix in the pandemic time where off-diagonal values are more heterogeneous with respect to the pre-pandemic period. The reproduction number was estimated to evaluate the impact of restrictions on the spread of COVID-19. The comparison with the pre-pandemic baseline shows a significant decrease in the number of contacts, independently from the age group or contact settings Fig.2. Moreover, Fig.3 shows that the decrease in the number of contacts significantly depends on the strictness of the non-pharmaceutical interventions (NPIs). For all levels of strictness considered, the reduction in social mixing results in a reproduction number (R_0) smaller than one. In particular, the impact of the restriction on the number of contacts decreases with the severity of the interventions.

The progressive restriction tiers implemented in Italy reduced the reproduction number, with stricter interventions associated with higher reductions Fig.4. This work shows that NPIs reduced the number of contacts independently by age group and contact settings. Second, we focus on the differences between the strictness of tiered restriction, marked by different color codes. All the interventions considered played an essential role to withstand the pandemic and were able to reduce R_0 below one, with stronger measures leading to a greater reduction of R_0. As the spread of COVID-19 evolves due to vaccination campaigns and new variants of concerns, continuous monitoring of social contact data can provide invaluable information to quantify the impact of social distancing policies and promptly design effective strategies to reduce the impact of the pandemic. Moreover, readily collected contact data can inform the implementation of mitigation measures at the national level in epidemic emergencies to come.

References

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Figure 1: Contact matrices for the adult population from the CoMix (a) and POLYMOD (b) data.

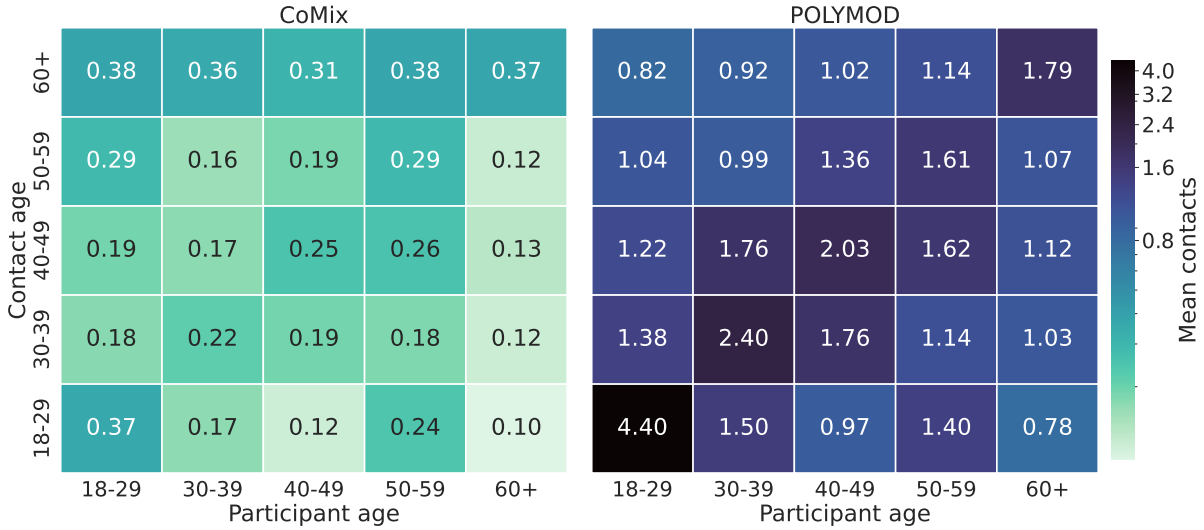

Figure 2: Average number of contacts from CoMix and POLYMOD data in all settings (a), at home(b), in other locations (c), and at work (d). Point symbols

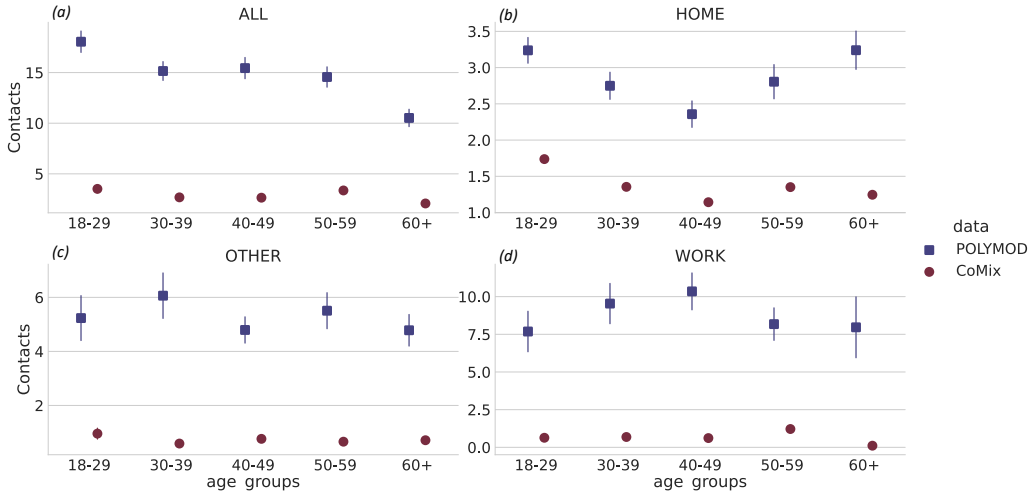

Figure 3: Average number of contacts broken down by age and zone for contacts reported at all locations (a), at home (b), at other locations (c), and at work (d). Point values correspond to the average value, while the error bars mark the sd. The color code indicates the NPIs, yellow for the lowest stringency regime, while red for the highest.

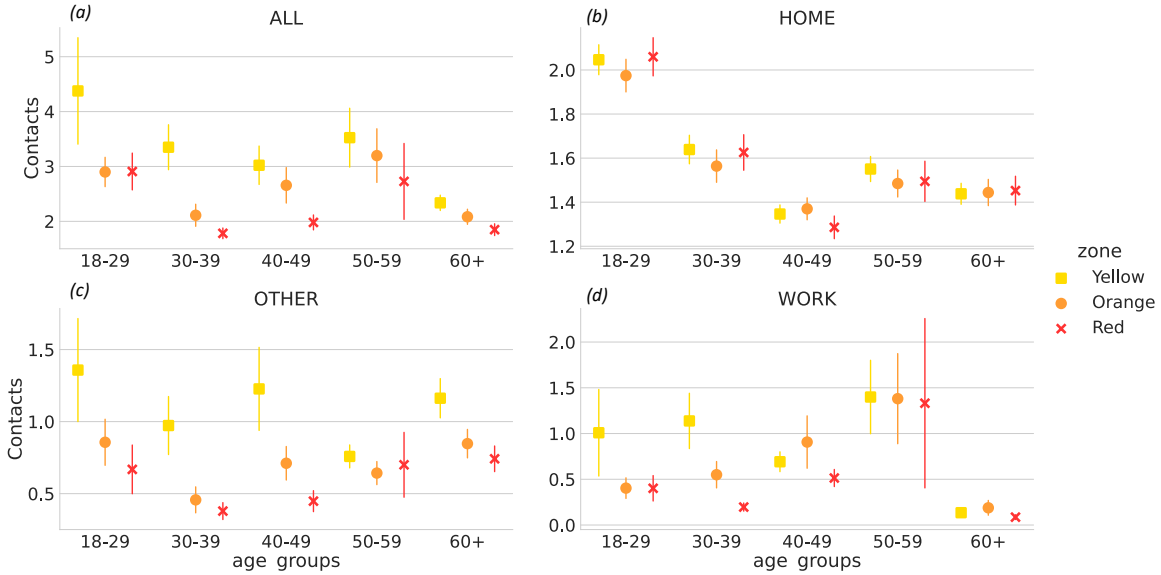

Figure 4: Reproduction number computed for each zone. The color code indicates the NPIs, Yellow for the lowest stringency regime, while Red for the highest.