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Effective Contact Tracing System Minimizes COVID-19 Related Infections and Deaths: Policy Lessons to Reduce the Impact of Future Pandemic Diseases

Igor Benati (Corresponding author)

CNR -- National Research Council of Italy

Collegio Carlo Alberto, Via Real Collegio, 30-10024 Moncalieri (Torino, Italy)

E-mail: igor.benati@ircres.cnr.it; mario.coccia@cnr.it

Mario Coccia

CNR -- National Research Council of Italy

Collegio Carlo Alberto, Via Real Collegio, 30-10024 Moncalieri (Torino, Italy)

E-mail: mario.coccia@cnr.it

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Abstract

One of the fundamental questions in the presence of Coronavirus Diseases 2019 (COVID-19) pandemic crisis and in general of new pandemic diseases is the planning of design effective policy responses to reduce the impact in the initial phase of diffusion, when appropriate therapies and drugs lack. This study analyses a prominent case study given by Italy, one of the first European countries to be damaged by the impact of COVID-19 pandemic in early 2020. In particular, this study focuses on health policy responses to the pandemic crisis between selected Italian regions (Veneto and Piedmont) that were the first areas to experience a rapid increase in confirmed cases and deaths of COVID-19. The analysis of early health policies, from February to July 2020 (during the first wave of the COVID-19 pandemic), reveals that some regions have managed this pandemic crisis with appropriate policy responses based on: a) timely and widespread testing of individuals, b) effective task force of epidemiological investigation in a pervasive contact-tracing system to detect and isolate all infected people. This health policy has reduced total deaths and negative effects of COVID-19 on people's health during the first pandemic wave, when pharmaceutical

interventions, such as vaccines and effective antiviral drugs were not available. This evidence here, in the first wave of the COVID-19 pandemic, provides important lessons to design an operational public health policy to constrain the diffusion of future infectious diseases and pandemic waves driven by new viral agents and subsequent variants, when effective drugs are not ready.

Keywords: COVID-19, Crisis management, Mitigation strategy, Contact-tracing system, Health policy, Regional systems, Pandemic crisis, Policy Making

Declaration of competing interest. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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1. Introduction

The SARS-CoV-2 is a new coronavirus that causes an infectious disease, the Coronavirus Disease 2019 (COVID-19), which is quickly spread worldwide generating a high number of deaths, economic and social problems (Bontempi, Coccia, Vergalli & Zanoletti, 2021; Bontempi & Coccia, 2021; Coccia, 2020, 2020a, 2020b; 2021, 2022; Núñez-Delgado et al., 2021). National and regional health policies play a central role to cope with the COVID-19 pandemic crisis and emergency situations in the presence of similar infectious diseases (Coccia, 2021a, 2021b, 2021c). Nicoll and Coulombier (2009, p. 3ff) argue that health policies to face pandemics can be based on:

- *Containment* policies that have the goal to interrupt transmission dynamics by strict interventions based on effective contact tracing, appropriate treatments and vaccinations (also compulsory), travel restrictions, school closures and commercial activities, quarantine and general lockdown (Coccia, 2021a, 2021b; 2022a).

- *Mitigation* policies that have the aim to reduce transmission dynamics of infectious diseases mainly with nonpharmaceutical measures having a lower degree of strictness, such as social distancing, facemask wearing, etc. (Askitas et al., 2021; Flaxman et al., 2020)

Containment and mitigation policies can reduce social pressure on hospitals and healthcare sector. In the presence of COVID 19 pandemic crisis and lack of appropriate therapies and drugs, many countries initially proposed containment policies (e.g., quarantine and general lockdown) and subsequently mitigation measures associated with pharmaceutical interventions (cf., Ardito, Coccia & Messeni Petruzzelli., 2021; Coccia, 2021a, 2021b, 2022c, 2022d; Kasis, Timotheou, Monshizadeh & Polycarpou, 2022; Flaxman et al., 2020; Kühn et al., 2022; Walensky & Del Rio, 2020). A fundamental question is the appropriate policy responses to cope with the initial phase of pandemic impact when pharmaceutical treatments lack or are ineffective measures. In this context, Romagnani et al. (2020, p. 238) analyze two Italian regions, Veneto and Lombardy, which implemented different strategies to infection control: “In Veneto, health personnel tested both symptomatic and asymptomatic subjects,

while in Lombardy only symptomatic cases were investigated". The purpose of the study here is to expand this research field with a comparative analysis of the initial health policies of two Italian regions Veneto and Piedmont that were the first areas to experience a rapid increase in confirmed cases and deaths of COVID-19. In particular, the first goal of this study is to compare these Italian regions' strategies directed to constrain the diffusion of COVID-19 with an approach of comparative performance systems (cf., Benati & Coccia, 2019). The second goal of the paper here is to determine what type of regional strategy is a more effective approach to cope with the spread of the COVID-19 and mitigate negative effects in society. Results of the study here can explain the weaknesses and strengths of different policy responses to suggest a more effective regional and/or national health policies to guide policymakers to face future epidemics similar to the COVID-19.

2. Study Design and Methods

 Data and sources

Epidemiological data of COVID-19 in Italy from February to July 2020 (first pandemic wave) of the Italian Department of Health (Ministero della Salute, 2020) are used.

 Measures

The number of confirmed cases and deaths of COVID-19 per million people in two Italian regions of Veneto and Piedmont.

 Methods and data analysis procedure

This study focuses on a main case study in Europe based on specific regions of North Italy (Veneto and Piedmont) that are the first areas to experience a rapid increase in confirmed cases and deaths of COVID-19. The methodology applies qualitative and quantitative techniques.

- Qualitative techniques, using information from regional orders and decrees, analyze health policy at national and regional level to cope with COVID-19 pandemic in Italy by a narrative approach based on a *temporal perspective* that shows and analyzes events of health strategies anti-pandemic crisis over time.
- Quantitative techniques here analyze the dynamics of COVID-19 related infected individuals and deaths in Veneto and Piedmont regions to determine the final impact of health policy responses. Moreover, trends of daily variation of deaths and confirmed cases in Veneto and Piedmont (i.e., deaths/confirmed cases at t – deaths/confirmed cases at t-1) are represented as function of time and estimated with Ordinary Least Square method using a quadratic model. Estimated relationships of Veneto and Piedmont regions are also analyzed with an optimization approach to calculate the max number of deaths per million in the peak of COVID-19 pandemic crisis in these two regions to assess the final effects of the first wave of COVID-19 pandemic in society.

3. Results

3.1 Research Setting: Italian Regions of Veneto and Piedmont

The comparative analysis of health policies is based in Veneto and Piedmont regions, which

have comparable demographic and socioeconomic characteristics (cf., Coccia & Benati, 2018). In particular,

- Veneto region, located in Northeast Italy, is one of the first regions, with Lombardy, to experience a rapid increase in the diffusion of COVID-19 but also in applying policy responses to cope with pandemic crisis. Socio economic indicators of this region are: population of about 4,909,013 inhabitants with a density of inhabitants per km^2 of about 268. Gross Domestic Product per capita (Euro) in 2017 is about €33,100 and regional health expenditure in 2018 is (in millions) €8,441.7 (ISTAT, 2020; Ministero dell'Economia e delle Finanze, 2019, cf., Coccia, 2021c).
- Piedmont region in Northwest Italy some weeks later than Veneto region, in February-March 2020, developed an outbreak of COVID-19. Piedmont is a comparable and representative region of other Italian regions in North Italy that applied general anti-pandemic measures. Socio economic indicators are: population of 4,356,406 inhabitants with a density per km^2 of about 172 inhabitants. Gross Domestic Product per capita in 2017 is about €30,300 and regional health expenditure in 2018 is (in millions) €9,400.3 (ISTAT, 2020; Ministero dell'Economia e delle Finanze, 2019).

3.2 Comparative Analysis of Regional Policy Responses to Constrain COVID-19 Pandemic Crisis in Veneto and Piedmont

The national health policy to constrain the COVID-19 pandemic crisis over 2020 year in Italy was aimed at reducing the spread of novel infectious disease for delaying and lowering the epidemic peak (Governo Italiano, 2022; OECD, 2020; cf., Peak, Childs, Grad, & Buckee, 2017). Many Italian regions applied only national guidelines of containment strictly, whereas some regions- using their administrative autonomy- also applied additional control measures that reinforced those of the Central Government. A comparative analysis between regional policies to cope with COVID-19 pandemic in Veneto and Piedmont provides interesting results.

- Veneto region

In Veneto region (Northeast Italy), on 21st February 2020, the town of Vò Euganeo near Padua city had a COVID-19 outbreak. In order to stop the diffusion of novel coronavirus, Veneto applied containment measures based on 14 days (from 23rd February to 8th March 2020) of full lock-down, quarantine and a ban of population movement: the so-called Red Zone (Lavezzo et al., 2020). In addition, all population of the town of Vò Euganeo was tested twice for detecting the novel coronavirus using nasopharyngeal swabs. This fieldwork, led by the University of Padua, clarified some key aspects of the transmission dynamics of the SARS-CoV-2 (e.g., the active role of asymptomatic people in the diffusion of infection) and triggered a learning process for supporting the strategy of containment of Veneto region (Lavezzo et al., 2020). As of 29th February 2020, 3% of the population in this town was found positive to the novel coronavirus and many people were asymptomatic (i.e., individual with a pathogen that does not show symptoms and can transmit it to others, developing symptoms in later stages of the infectious disease). People with positive nasal and oropharyngeal swab tests (i.e., having the COVID-19) were placed in home isolation: the

spread of COVID-19 had been stopped, and no new cases were identified in the town of Vò Euganeo at the end of March. The strategy of swabs in Veneto region was implemented with the Regional Decree No. 344 on 17th March 2020 (Regione Veneto, 2020). The experiment in the town of Vò Euganeo in Veneto suggested that a widespread testing of people with no symptoms, associated with isolation of infected individuals, was a critical health strategy to control and stop, whenever possible, the spread of COVID-19 pandemic. Hence, using the know-how of the University of Padua in the outbreak of Vò Euganeo, innovative health policy of Veneto focused on an effective contact tracing system based on a proactive strategy for detecting the COVID-19 through the extensively use of nasal and oropharyngeal swab tests across the population. In particular, the health policy anti-COVID-19 by Veneto region is based on following strategy:

- *General goal*: "to stop the transmission chain of the virus responsible for COVID-19" in the population through identification of "positive" paucisintomatic and asymptomatic subjects, enlarging the home isolation around the "positive" case having COVID-19 (Regione Veneto, 2020a).
- *Specific sub-objectives* given by:
  - identify all possible suspicious, probable and confirmed cases of people with COVID-19
  - apply the measures of quarantine and fiduciary home isolation for all people having contacts with infected individuals
  - find all positive cases of COVID-19 in employees of Essential Services (health sector, public safety, etc.).

The use of a proactive widespread testing strategy in Veneto, in a context of effective contact tracing system, was unique among all Italian regions.

The implementation of this strategy was based on four main elements:

- *Target population*

  a) individuals potentially connected to a cluster of infected people (e.g., in family, at workplace, or with social /occasional contacts of suspicious or confirmed cases) or to a confirmed or probable case of COVID-19. The investigation of contacts is focused on previous 48 hours from initial symptoms to the diagnosis and home isolation;

  b) healthcare employees and essential services employees, such as employees of shopping malls, firefighters and police officers.
- *Nasal and oropharyngeal swab tests*. The requests for swabs have been done by General Physicians and Pediatricians of Territorial services that transmit appropriate information to Territorial Operational Unit (COT) of the Local Health Unit, or by other medical specialists that had to report them to Public Health Hygiene Service (SISP).
- *Epidemiological investigation* was based on increasing concentric cycles of inquiry, starting from individual, possible contacts in family and at workplace at high risk, to social and occasional contacts at low risk. In the presence of a confirmed case, all contacts had to stay in home isolation. Confirmed cases were subjected to an "active surveillance" in isolation (with daily follow-up telephone call or with a telemedicine service).

To implement this anti-COVID-19 health policy, the Veneto region used 13 laboratories for testing the SARS-CoV-2. In short, health policy in Veneto involved the use of an effective contact tracing system based on a proactive strategy of nasal and oropharyngeal swab *tests* to symptomatic and asymptomatic people, with an in-depth epidemiological inquiry for detecting all contacts and subsequently home isolation of confirmed cases and suspected people.

- Piedmont region

In Piedmont region, by contrast, the first confirmed case of COVID-19 was detected on 22 February 2020. The day after, the regional government adopted national guidelines of the Health Ministry of Italy, stating the suspension of all events, crowding of people, the closure of children's education services, schools, universities, museums, and other cultural places (Regione Piemonte, 2020). Because of the growing number of confirmed cases of COVID-19, on 9th March 2020, the government of Italy imposed a national lockdown, restricting the movement of the population. This region applied containment measures in accordance with national guidelines of Italy with a strategy of confirmative swabs for infected and suspected people. In particular, nasal and oropharyngeal swab tests were used only to confirm symptomatic suspect cases and to certify healed individuals; in Piedmont, there was no testing for searching asymptomatic people of COVID-19 like in Veneto region. This initial approach by Piedmont region, and Italy, did not consider new studies on novel coronavirus, such as Kucharski et al. (2020) that argue how COVID-19 begins (incubation) and can be spread before the emergence of minor and/or major symptoms. Hellewell et al. (2020) show that the growth of transmission dynamics of COVID-19 can be due to a wide interval between the detection of individuals with emerging symptoms and their isolation in appropriate structures. Piedmont made nasal and oropharyngeal swab tests both in hospitals, at home and in the car but general physicians were authorized to order swab tests from May 11, 2020, in the maturity phase of the COVID-19 outbreak in Italy and about three months later than Veneto region. In addition, at the beginning of COVID-19 pandemic, Piedmont had only two laboratories for nasal and oropharyngeal swab tests with the capacity of making about 400 swabs per day, whereas Veneto had 13 active labs for testing COVID-19 from 17th February 2020 onwards. Later, the capability of COVID-19 tests in Piedmont had been greatly increased, with the opening of new labs but the COVID-19 pandemic wave had already generated issues for public health and society of Piedmont region. In short, Piedmont did not apply an active strategy of nasal and oropharyngeal swab tests to detect symptomatic and asymptomatic cases, nor in-depth epidemiological inquiries of people who have had social and occasional relationships with infected people of COVID-19.

- Comparison of Veneto and Piedmont

Veneto and Piedmont regions reorganized their healthcare facilities for COVID-19. In particular, Veneto and Piedmont have set up specialized hospitals to treat patients with COVID-19 and increased the number of Intensive Care Units (ICUs). Veneto increased ICUs from 494 to 825 on 29th April 2020; Piedmont, from 327 to 827 ICUs at the same date.

About laboratories for testing the SARS-CoV-2, Veneto had the operational capacity of 13

laboratories throughout the pandemic crisis, whereas Piedmont had only two laboratories at the beginning of the COVID-19 pandemic crisis, subsequently, it has increased to a total of 20 laboratories in the phase of maturity of the first pandemic wave of COVID-19 in 2020. These regions applied, in general, containment measures based on national guidelines of Italian government. However, unlike Piedmont region, Veneto integrated containment measures with an effective contact tracing system based on proactive nasal and oropharyngeal swab tests for symptomatic and asymptomatic people and task force for in-depth epidemiological inquiry of infected cases, creating a fruitful combination to stop as many transmissions as possible and reducing COVID-19 outbreaks. Health policies of Veneto and Piedmont regions are summarized in table 1

Table 1. Comparative health policy responses in Italian regions of Veneto and Piedmont

Dimensions	**Veneto**	**Piedmont**
General strategy	*Containment oriented-reinforced*	*Containment oriented*
Goal	To stop transmission chain Find asymptomatic individuals Confirm symptomatic individuals Certify healed individuals	To reduce the diffusion of pandemic Confirm symptomatic individuals Certify healed individuals
Implementation	*Proactive testing and tracing of SARS-CoV-2*	*Confirmative testing of SARS-CoV-2*
Starting point of pandemic	Initial localized outbreak in a town	No initial localized outbreak, but isolated cases
Population target	Symptomatic and asymptomatic	Symptomatic
Epidemiologic inquiry	In-depth investigation to track all relationships of people infected (family, colleagues, social and occasional contacts)	Basic, concerning only family and colleagues
Type of testing	Nasopharyngeal and Oropharyngeal Swabs	Nasopharyngeal and Oropharyngeal Swabs + tentative serology test for COVID-19
Location for testing	Hospital Home (from March 17th) Car (from March 23rd)	Hospital Home (from April 8th) Car (from April 2nd)
People that authorize testing	General Physician and Pediatricians (from March 17th) Hospital medical staf	General Physician (from May 11th) Hospital medical staff
Structure for authorizing test	Territorial Operational Unit	Public Health Hygiene Service
Rules for people infected	Quarantine Home isolation also for suspected people Hospitalization with symptoms	Quarantine Home isolation Hospitalization with symptoms
*Number of initial ICU**	494 (14 March 2020)	327 (14 March 2020)
*Number of final ICU**	825 (29 April 2020)	827 (29 April 2020)
Number of initial lab for testing	13 (17 March 2020)	2 (22 February 2020)
Number of final lab for testing	13 (June 2020)	20 (June 2020)
Actors involved	Crisis Unit - Public Health Hygiene Service -Universities	Crisis unit-Hospitals

Note: *ICU=Intensive Care Unit

3.3 Trends of the COVID-19 in Veneto and Piedmont

The comparative analysis of COVID 19 pandemic, based on deaths and swab tests in Veneto and Piedmont, shows some relevant results of different effects of health policies implemented by these regions from stage 1 of containment (about February - May 2020 period) to stage 2 of mitigation measures (from June 2020 onwards).

Figure 1 shows that trend of swabs in Veneto is always higher than Piedmont region. In addition, figure 1 reveals that at the beginning of the COVID-19 outbreak, Veneto and Piedmont had similar trends of deaths per million people. However, since mid-March 2020, Veneto has recorded a systematically number of deaths (per million) lower than Piedmont region. This evidence, using confirmed cases, number of swabs and total deaths, suggests that innovative health policy applied by Veneto–based on an accurate contact-tracing system– has been more effective to cope the COVID-19 pandemic, reducing the negative effects of pandemic on health of people and society.

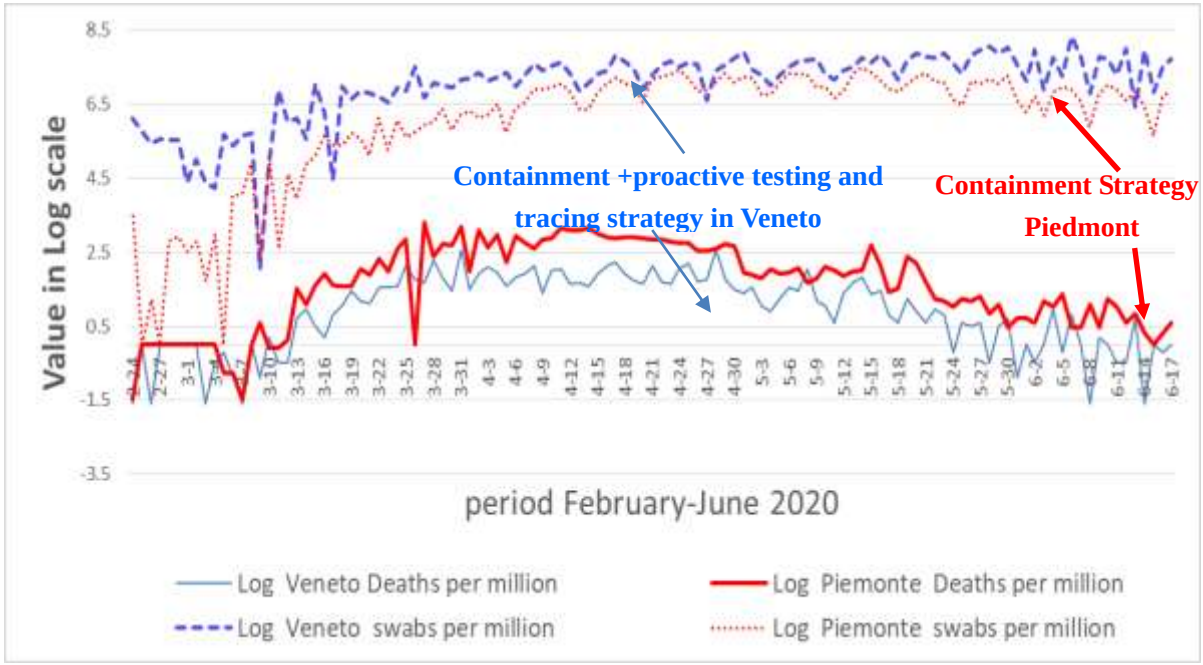

Figure 1. Trends of deaths and nasal and oropharyngeal swab tests in Italian regions of Veneto and Piedmont

The statistical models show that approximately 60% of the observed variation of COVID-19 related deaths can be explained by independent variable of time. The application of optimization technique on estimated relationships in figure 1 shows that the peak of deaths is about at 56th day from 24th February 2020 both in Piedmont and Veneto region. However, a main difference is given by max number of total deaths in estimated relationships: Veneto has a number of total deaths equal to 6.12 per million people, a value that is less than half compared to Piedmont (given by 14.02 deaths per million people). To put it differently, Piedmont has had higher (+129.0%) total deaths in the peak of COVID-19 than Veneto!

Results show that Veneto, with an appropriate governance and effective institutions, has implemented a containment strategy based on an effective contact-tracing system with a high number of nasal and oropharyngeal swab tests to detect symptomatic and asymptomatic people and task forces for in-depth epidemiological inquiries that have reduced the total number of deaths of about the half compared to Piedmont region (Benati & Coccia, 2022; Chowdhury et al., 2022; Coccia, 2018).

Table 2 confirms the effectiveness of regional policy responses by Veneto based on a widespread contact-tracing system to cope with the COVID-19 pandemic crisis. Furthermore, this health policy suggests an effective strategy to face future pandemic threats similar to the COVID-19 (Amara et al., 2022; Coccia, 2021d, 2021e; 2022b, 2022d; Herrero et al., 2022).

Table 2. Effects of COVID-19 pandemic crisis in Italian regions of Veneto and Piedmont

Indicators of the pandemic impact	**Veneto**	**Piedmont**
Confirmed cases on 7 July 2020	19,327	31,429
Nasal and oropharyngeal swab *tests* on 7 July 2020, number	1,013,235	431,761
Total deaths on 7 July 2020	2,014	4,104
(infected/swabs)% on 7 July 2020	1.91	7.28

4. Discussions

This study focuses on Italy, a particularly interesting case study because national containment policy was implemented with different modes and timing and/or integrated by regions with additional health policies. This variety of regional applications of national orders, coupled with regional health system and other factors, has produced different public health interventions to face COVID-19 and different effects on health of people (cf., Coccia, 2018, 2021a, 2021b).

Figure 2 compares the health policy applied by Veneto and Piedmont regions.

On one hand, Veneto with an effective contact tracing system adopted a proactive testing strategy for detecting suspicious, probable and confirmed cases; moreover, the regional Public Health Hygiene Service carried out an in-depth epidemiological investigation by specific task forces of the Department of Prevention, which was able to guarantee nasal and oropharyngeal swab tests to paucisintomatic or momentarily asymptomatic subjects potentially linked to a cluster of infected individuals (cf., Regione Veneto, 2020). The outcome of this effective contact tracing system was the reduction of the period from symptom onset to isolation that reduces human-to-human transmission and, as a consequence, mitigates the effects on people's health with a lower number of deaths.

On the other hand, Piedmont did not design, like Veneto, complementary measures based on a proactive testing strategy of asymptomatic subjects and systematic epidemiological inquiries of all contacts of confirmed cases but it applied only the general indications of national government of Italy. The outcome is a longer delay from symptom onset to isolation that increased the transmission of COVID-19 in society and negative effects in terms of a

higher number of deaths.

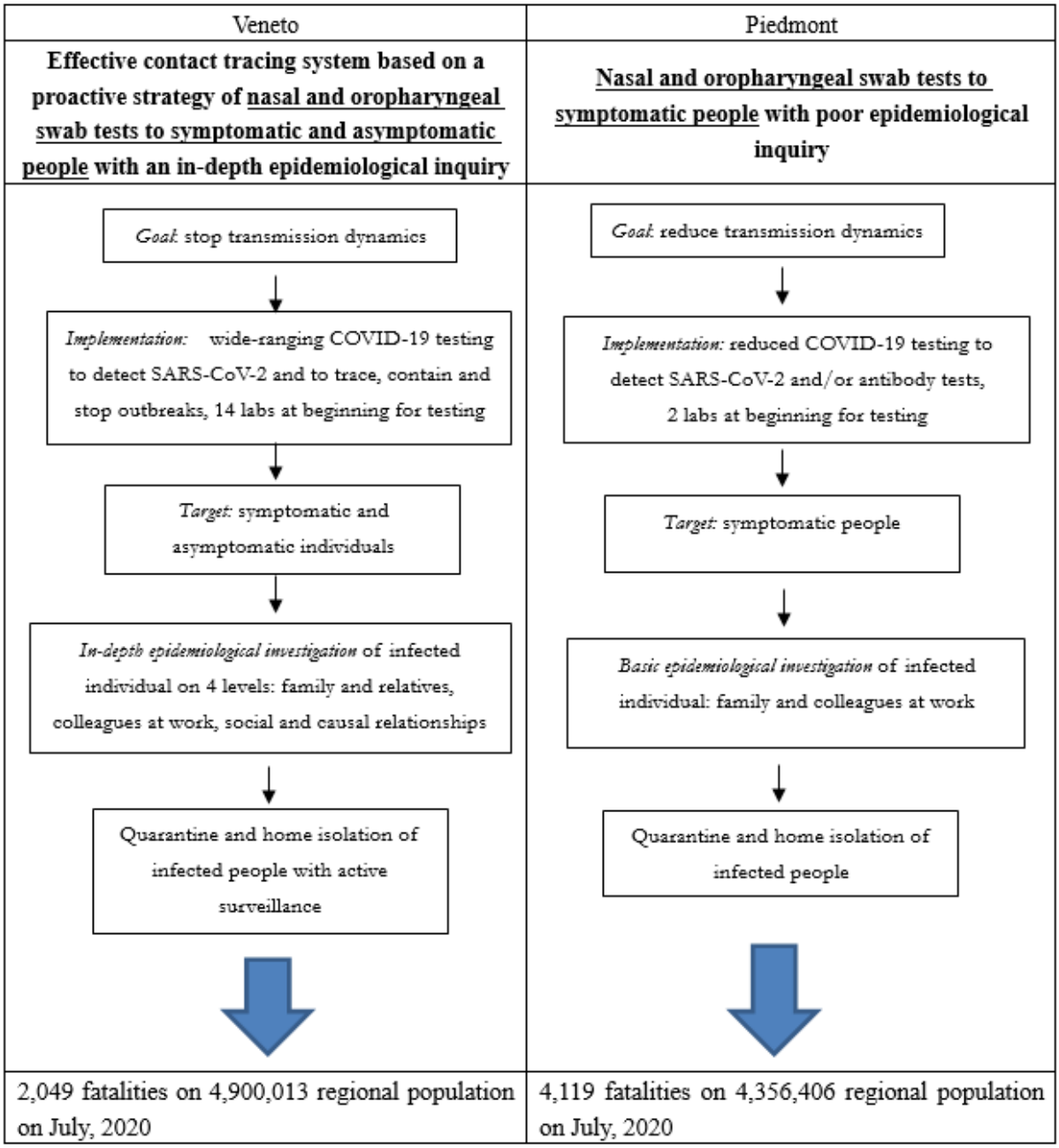

Figure 2. Different health policy responses in Italian regions of Veneto and Piedmont to the COVID-19 pandemic crisis

5. Policy Implications and Conclusions

Results of this study provide main public policy implications to cope with next pandemics similar to COVID-19. In particular, policy recommendations are that Veneto, with a health policy of containment (general lockdown) reinforced with an effective contact tracing system based on a high number of nasal and oropharyngeal swab tests to detect symptomatic and asymptomatic people and dynamic task forces for in-depth epidemiological inquiries has reduced total number of deaths and negative effects of COVID-19 pandemic in society (Kasis

et al, 2022; Kühn et al., 2022; Proesmans et al., 2022).

Lessons learned of this study can be generalized in other contexts by suggesting the opportunity to support good governance of nations and regions in order to apply a timely policy response based on scientific and technical expertise of academic institutions for guiding decision making of policymakers (cf., Cairney, 2016; Coccia, 2021a, 2021b; Romagnani et al., 2020; Scarselli, Budanur, Timme, & Hof, 2021). Benati and Coccia (2022) point out the positive effects of good governance in supporting the prompt implementation of policy responses to cope with pandemic crisis, mitigating fatality rates. In addition, lessons learned from Veneto in Italy suggest that learning processes based on the initial outbreak in the town of Vò Euganeo have improved the decisions of policymakers to design and implement effective policy responses to stop the transmission dynamics of COVID-19 (cf., Coccia, 2019; Crow, Albright, Ely, Koebele & Lawhon, 2018; Lavezzo et al., 2020; Weible et al., 2020).

Hence, these findings here can help policymakers to gain new knowledge to improve crisis management for next pandemic threats (Coccia, 2021e). A main plan is the improvement of the governance of regions and the preparedness to face new pandemic crises with appropriate social norms, organizational units, regulations, and new technology ready to support operating centres for emergencies (Coccia & Bellitto, 2018; Coccia and Benati, 2018a). Coccia, 2018; 2020c, 2021d, 2022b). Overall, then, this study shows that a regional health policy of containment and mitigation measures, reinforced with an effective contact tracing system based on proactive testing of people, task forces for in-depth epidemiological inquiries on a large scale, and new technology (e.g., high-tech medical ventilators) in hospitals can reduce total deaths and negative impact of pandemics of new viral agents similar to SARS-COV-2. However, these conclusions are of course tentative and there is need for much more research into the relations between pandemic impact, governance and implementation of appropriate policy responses, considering manifold confounding and situational factors, to improve preparedness of crisis management for next pandemic threats.

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