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Analysis of Data on Coronavirus Morbidity in Children[1]

According to the insights of the Ministry of Health and according to a recently published article[2] on the question of opening schools, three issues must be addressed – whether children are infected, whether it is possible to identify infected children, and what the behavioral characteristics of children that can affect infection are.

Abstract

Key results

1. Since children were first tested in Israel on January 27, 2020, and up until September 24, 2020, 677,982 RT-PCR tests have been performed on children. Of these, 55,288 (8%) were positive. In comparison, 157,229 out of 2,548,273 (6%) were positive among adults. **This finding proves that morbidity rates are higher in children than in adults.**

2. This result is also supported by the findings of the national serology survey conducted by the Ministry of Health between June 28 – September 14 covering the entire population in Israel[3]. A 7.1% positive rate was seen among children was found compared to 1.7%-4.8% in adult age groups.

3. The data reveals that in the various age groups, 51%-70% **of all verified infected children are asymptomatic**. Asymptomatic children constitute a reservoir for infection among children and for the entire population.

4. According to data from epidemiological investigations, most children who reported a source of infection were infected due to contact with an adult (80% of known cases) and 20% were infected due to contact with children, primarily of their own age or those close to them in age.

5. A transmission chain analysis indicates that infecting children facilitates the creation of additional generations, which manifest in different age groups and transmission between

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[1] The report was prepared by the Epidemiology Division and the Mother, Child and Adolescent Department of the Public Health Services in collaboration with the National Coronavirus Information and Knowledge Center

[2] Davies, N.G., Klepa, P., Liu, Y. *et al.* Age-dependent effects in the transmission and control of COVID-19 epidemics. *Nat Med* 2020;**26**: 1205-1211

[3] https://www.gov.il/he/departments/news/08102020-01

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different geographic regions. 17 cases of children who had infected at least 10 people were found.

6. An additional analysis that includes data from the date of **opening of the education system (September 1, 2020) shows a significant increase** in the rate of verified cases both at education system age and in older populations, whereas **the closing of the education system** due to the increase in morbidity parameters **indicated a significant decrease** in the rate of verified cases, both among education system age individuals and in the general population. The increase in morbidity differed between different age groups, meaning that the risk for morbidity was higher with increasing age.

Conclusions

1. According to the analysis provided above, children are certainly infected and infect others. Because most of them do not present symptoms, it is difficult to identify a signifcant portion of children carrying the virus, and they may constitute a source for infecting others.

2. The presence of children in educational settings, especially at a time of extensive morbidity, may expedite the spread of the disease, both in different age groups and in different geographical regions.

3. Gradual return of the educational system to operation, according to the morbidity level in different age groups and in different geographical regions, is of great importance.

Introduction

1. The first reports in literature indicate variance in aspects of infection, onset of and severity of symptoms in children (0-17, inclusive) relative to the adult population (above 18 years age). An analysis of child morbidity trends is important for policymaking and for making decisions that help cope with the consequences of coronavirus.

2. On October 5, 2020, a report on child morbidity in Israel in the context of the opening of the educational system was published.[4] **The current report describes the infection trends in children since the beginning of the pandemic and expands and elaborates on the significance of infection among children and the significance of this infection**

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[4] https://www.gov.il/he/departments/publications/reports/research-report-n183-youth-morbidity-increase

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for the spread of the coronavirus in the general population, including the effect of opening the school year, given the high morbidity figures.[5]

Morbidity characteristics – symptoms

1. The figures show that in the various age groups, 51%-70% **of all verified children are asymptomatic**. It should be noted that the information on symptoms is based on the reporting in the epidemiological investigation. For cases in which symptoms have not been reported **or in cases in which symptoms were reported after the investigation, these are considered as asymptomatic in this analysis.**

2. Figure 1A shows types of symptoms that characterize clinical manifestation of the disease and their rate in children by age group. The calculation was made based on all verified cases in those age groups. The most common symptoms, irrespective of age group, are: Fever, headache, and cough.
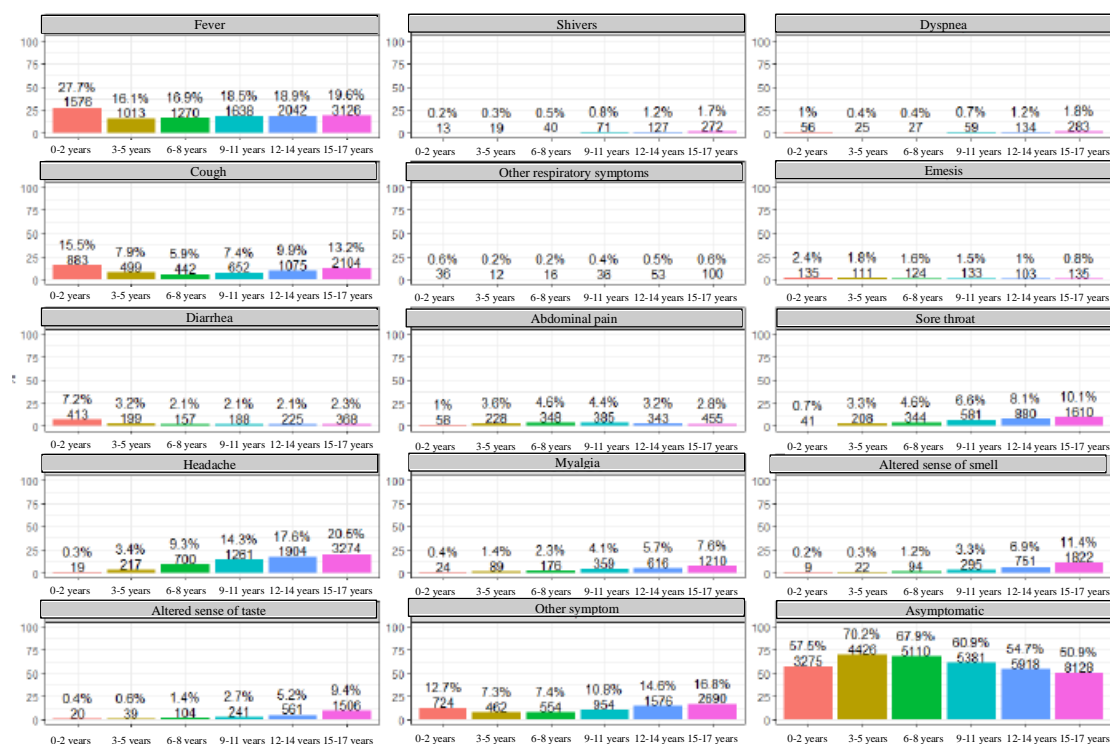
Figure 1A. Distribution rate of symptoms in verified cases by age group
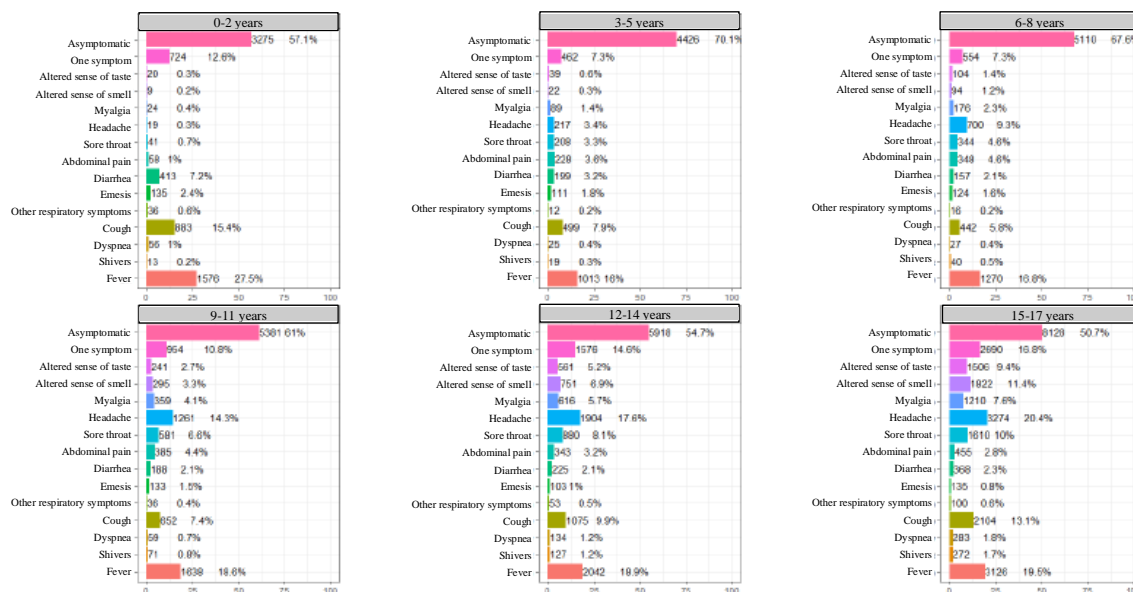
3. Figure 1B shows the symptoms of verified cases in each age group (0-17, inclusive).

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[5] Kevin AAm, Halperin S. Covid-19 in children: the link in the transmission chain. Lancet Infec Dis 2020; 20; 633-634

Figure 1B. Age groups by symptoms of verified cases

4. The lack of symptoms in verified children is a phenomenon that is also reported in other studies in the literature.[6] The findings in this report support the frequency of the phenomenon.

**Morbidity characteristics – degree of severity**

1. The Ministry of Health has defined the disease severity level in inpatients in a procedure that was published on July 12, 2020.[7]

2. The absolute majority of verified children who had Covid-19 symptoms experienced the disease mildly. Out of symptomatic verified children, 31 experienced symptoms at a moderate level and 28 at a severe level.

3. In the report period, 494 children were hospitalized. This number constitutes less than 1% of the total number of verified children.

4. Figure 2 shows the number of inpatients during the report period by age group and medical condition severity. It shows that in most cases, inpatients were in mild condition.

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[6] DeBiasi RL, Delaney M. Symptomatic and Asymptomatic Viral Shedding in Pediatric Patients Infected with Severe Acute Respiratory syndrome Coronavirus 2 (SARS-CoV-2): under the Surface. *JAMA Pediatr.* Published online August 28, 2020. Doi:10.1001/jamapediatrics.2020.3996
[7] https://www.health.gov.il/Subjects/disease/corona/Documents/mr-294754420.pdf

The number of cases in the 0-2 year age group is higher than that of the other age groups

due to the hospitalization policy for this age group.

Figure 2. Number of inpatients by age group and medical severity
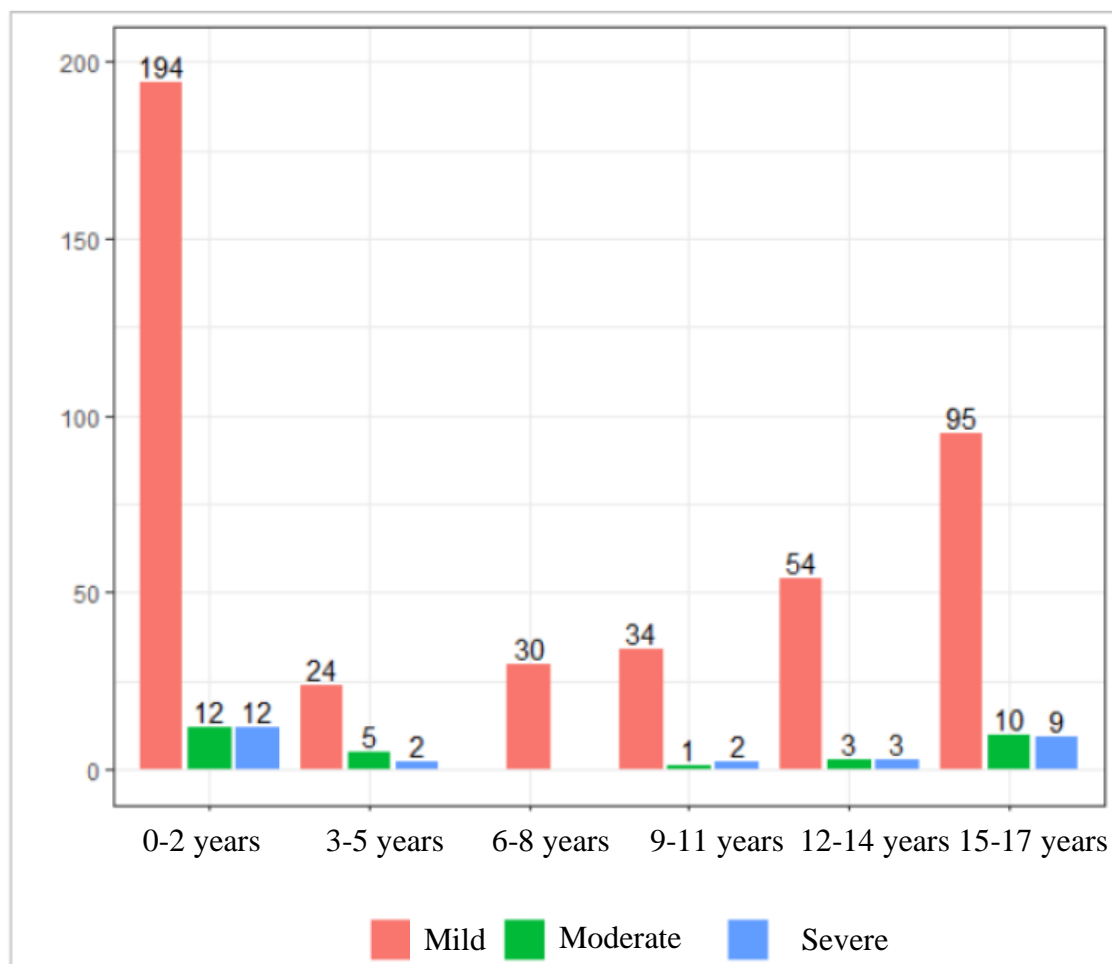
Morbidity characteristics – underlying conditions

1. Within the epidemiological investigation, 1,461 children, constituting 2.5% of all verified
   children, were reported as having an underlying condition. The most common reported
   underlying conditions are: Asthma 0.53% (294), chronic lung disease 0.21% (114), and
   heart disease 0.12% (69).

Are children infected?

Performing and results of RT-PRC tests

1. Since performing the first test in children in Israel on January 27, 2020 and up until September 24, 2020, 677,982 RT-PCR tests have been performed on children (0-17 years, inclusive). Out of these, in 55,288 (8.3%) the result was positive.

   In figure 3, one can compare the percentage of positive tests in four age groups. The percentage of positive tests of all children **is higher than that of the adult age groups.**

Figure 3. Comparison of the percentage of positive tests by age groups (January 27 - September 24)
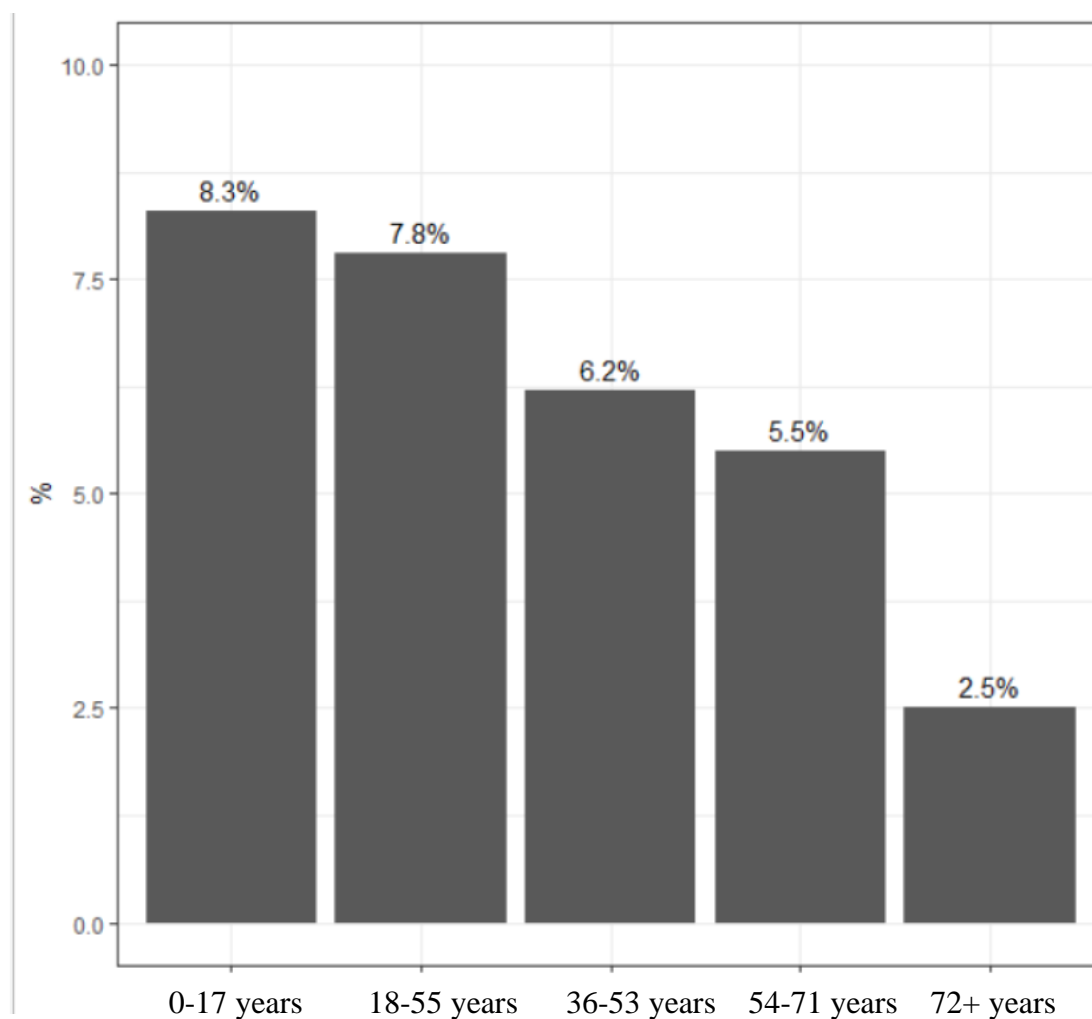
2. Figure 4 shows the number and percentage of children out of the entire population in Israel (2019), the number and percentage of tests done on children out of all tests done, the number and percentage of verified children out of children of the same age group in the population.

Figure 4. Comparison of characteristics by age groups (January 27 – September 24)
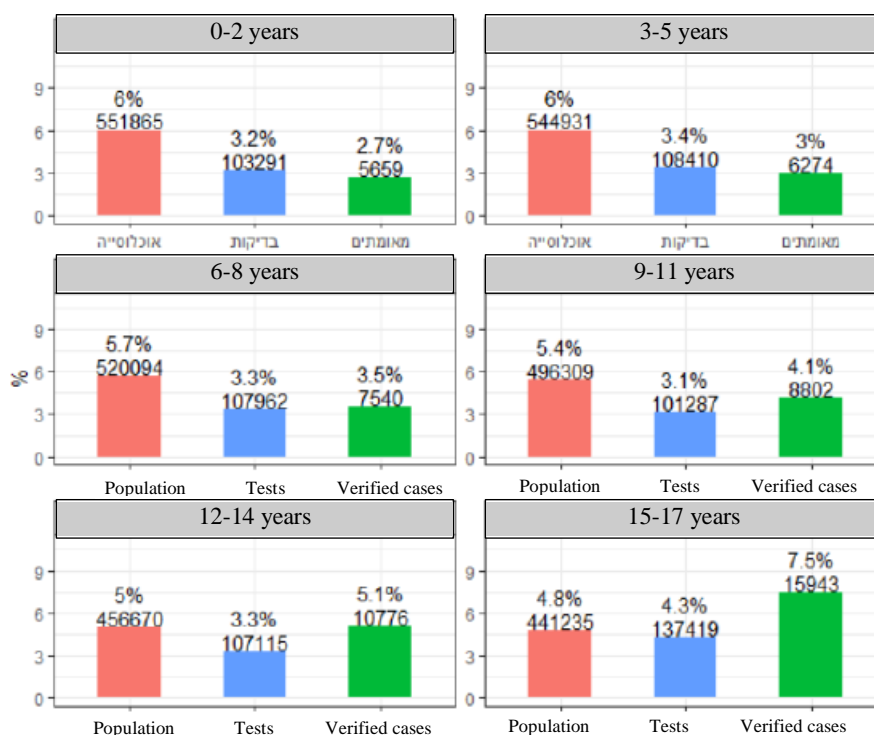
3. RT-PCR tests have been done primarily in children who meet criteria that raise suspicion of Covid-19 morbidity. Given the high number of asymptomatic children, the true number of verified cases in the population is higher.

Serological screening

The Ministry of Health conducted national serological screening on June 28 – September 14 in the general population in Israel[8]. The screening was done by means of blood tests through healthcare organizations on people who arrived to be examined for any reason.

The screening included 4,874 children (0-17 years, inclusive), of whom 345 were found positive, i.e. a rate of 7.1% positive out of all subjects. This finding supports the conclusion that transmission to children is higher than assumable according to RT-PCR tests alone.

Do children transmit the virus?

1. In an epidemiological investigation, the infected individual is questioned about the source of his infection. Out of 212,304 verified cases of all ages on January 27 – September 24, the epidemiological investigation contained information about the transmitting individual

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[8] https://www.gov.il/he/departments/news/08102020-01

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in 67.3% of cases, out of whom there is information on the age on the transmitting and infected individual in 87.8% of cases.

Figure 5A. Who infects whom? Age groups of transmitting individuals compared to age groups of infected individuals

Transmitters	0-2 years	3-5 years	6-8 years	9-11 years	12-14 years	15-17 years	18-120 years
Unknown	14.8% (840)	17% (1072)	16.6% (1282)	16.2% (1435)	28% (3040)	46.5% (7459)	45.7% (71422)
18-120 years	69.5% (3989)	63.6% (4020)	61.2% (4624)	60.2% (5311)	51.5% (5572)	37.3% (5973)	48.1% (75453)
15-17 years	2% (115)	2.9% (185)	3.7% (279)	5.3% (465)	6.7% (725)	9.8% (1577)	2.4% (3818)
12-14 years	2.1% (123)	2.5% (159)	4.1% (307)	5.4% (481)	6.3% (677)	3.1% (498)	1.2% (1932)
9-11 years	2.6% (151)	3.3% (207)	4.8% (360)	5.8% (491)	3.7% (403)	1.6% (258)	0.8% (1327)
6-8 years	2.8% (162)	4% (250)	4.6% (345)	3.7% (328)	2.1% (224)	0.9% (139)	0.6% (992)
3-5 years	3.4% (196)	3.7% (235)	3.3% (251)	2.2% (194)	1% (106)	0.5% (74)	0.6% (876)
0-2 years	2.8% (160)	3% (188)	1.7% (132)	1.4% (122)	0.7% (78)	0.3% (46)	0.6% (972)

Infected

2. Figures 5B, 5C and 5D examine intra-sectorial infection patterns by sector.

Figure 5B. Who infects whom? Age groups of transmitting individuals compared to age groups of infected individuals in the general population

Transmitters	General						
	0-2 years	3-5 years	6-8 years	9-11 years	12-14 years	15-17 years	18-120 years
Unknown	24.5% (697)	28.8% (1000)	24.7% (937)	22.8% (912)	31.2% (1420)	43.3% (2884)	49.1% (43412)
18-120 years	62.2% (1768)	55.6% (1925)	55.3% (2104)	56.3% (2268)	48.6% (2212)	37.9% (2528)	45.6% (40294)
15-17 years	1.2% (35)	1.5% (51)	2.4% (90)	4.1% (167)	6.6% (301)	13.3% (887)	1.9% (1690)
12-14 years	1.4% (39)	1.4% (49)	3.1% (119)	4.2% (171)	6.8% (311)	2.9% (193)	0.9% (770)
9-11 years	1.9% (54)	2.3% (80)	4.1% (154)	5.8% (233)	3.4% (157)	1.3% (90)	0.7% (586)
6-8 years	2.3% (65)	3.5% (121)	5.5% (211)	3.7% (151)	2.2% (99)	0.7% (49)	0.6% (523)
3-5 years	3.5% (100)	4.3% (148)	3.3% (126)	2.1% (84)	0.8% (35)	0.4% (29)	0.6% (508)
	3% (84)	2.6% (89)	1.6% (61)	1% (41)	0.4% (18)	0.2% (11)	0.6% (492)

Infected

Figure 5C. Who infects whom? Age groups of transmitting individuals compared to age groups of infected individuals in the ultra-Orthodox sector

Transmitters \ Ultra-orthodox	0-2 years	3-5 years	6-8 years	9-11 years	12-14 years	15-17 years	18-120 years
Unknown	11.1% (202)	5.4% (99)	10.8% (273)	14% (454)	32.7% (1449)	59.6% (4166)	60.7% (22813)
18-120 years	67.5% (1230)	65.8% (1197)	60.9% (1514)	57.4% (1876)	45.9% (2040)	27.4% (1922)	31.1% (11674)
15-17 years	3.2% (59)	6% (109)	6.3% (156)	7.2% (235)	7.1% (315)	5.7% (403)	2.9% (1073)
12-14 years	3.4% (62)	4.9% (89)	6.5% (161)	7.4% (242)	5.5% (243)	3.5% (247)	2.1% (795)
9-11 years	4.1% (74)	5.5% (100)	6.3% (156)	5.6% (182)	4.3% (193)	1.8% (127)	1.3% (485)
6-8 years	4.1% (74)	5.5% (100)	3.5% (86)	4.1% (135)	2.3% (102)	1.1% (80)	0.8% (289)
3-5 years	3.9% (71)	3% (54)	3.6% (89)	2.4% (79)	1.2% (55)	0.5% (38)	0.5% (197)
0-2 years	2.7% (49)	3.9% (71)	2.1% (53)	1.9% (63)	1% (45)	0.4% (27)	0.6% (240)

Infected

Figure 5D. Who infects whom? Age groups of transmitting individuals by age groups of infected individuals in the Arab sector

Transmitters \ Arab	0-2 years	3-5 years	6-8 years	9-11 years	12-14 years	15-17 years	18-120 years
Unknown	19% (205)	24.4% (251)	24.8% (315)	24.7% (381)	30.6% (559)	37.9% (886)	43.3% (13397)
18-120 years	70.9% (762)	63.3% (655)	61.3% (779)	59.8% (917)	55.8% (1022)	51.5% (1206)	51.1% (15809)
15-17 years	1.5% (16)	1.7% (18)	2% (25)	3.4% (52)	4.5% (83)	6.7% (157)	2.7% (841)
12-14 years	1.6% (17)	1.4% (14)	1.9% (24)	3.5% (53)	4.2% (76)	1.7% (41)	0.8% (261)
9-11 years	1.6% (17)	2.3% (24)	3.3% (42)	3.7% (57)	2.7% (50)	1.5% (35)	0.7% (205)
6-8 years	1.5% (16)	2.2% (23)	3.5% (44)	2.5% (38)	1.1% (20)	0.3% (8)	0.4% (134)
3-5 years	1.8% (19)	2.6% (27)	2.3% (29)	1.6% (24)	0.7% (12)	0.3% (7)	0.4% (127)
0-2 years	2.1% (23)	2.1% (22)	0.9% (12)	0.8% (12)	0.4% (8)	0.1% (3)	0.6% (177)

Infected

3. Most children for whom the age of the transmitting individual and infected individual was known were infected by an adult (73.4% of cases). In 26.6% of cases the children were

infected by other children (primarily of their own age or close to their age). These figures correspond with those of other studies.[9][10]

4. In the general sector and in the Arab sector, infection of children concentrates mostly in their own age groups and groups close to their age. In the general sector, transmission to 15-17 year-olds is relatively high, standing at 14%.

   In the ultra-orthodox sector the older age groups infect the younger ones. This analysis does not relate to relations between sectors.

5. In an analysis of a number of people who infected at least 10 people, 350 such individuals have been found in all age groups. Out of these, 17 were children up to 17 years of age: 7 of them infected 10 people each, 3 children infected 12 people each one child infected 24 people.

The transmission chain

1. The consequences of transmission that begins in children can be studied from transmission chain analysis. This analysis shows a picture of extensive impact in educational settings.

2. A 'transmission chain' is a means of graphic display of the relationship between infecting and infected individuals by various variables and over time. A transmission chain is built digitally using a decimated tool based on information from epidemiological investigations. This section describes a sample of a transmission chain that started at a primary school. This way one can see the development of transmission between age groups and different towns on a temporal axis.

3. This transmission chain developed over approximately two weeks and consists of 79 involved individuals, including 5 teaching staff members and 20 students of both sexes.

4. Figure 7A shows the transmission chain by age group. The age groups ranges from 0 to 64, the mean age being 27. It is demonstrated that some of the transmission occurs within the age groups themselves, and the transition between age groups is also demonstrated.

5. In generation 0, the transmission site is the school. Afterward, the transmission continues to the houses and families of infected individuals.

[9] Posfay-Barbe KM et al Covid 19 in Children and the dynamics of infection in families. Pediatrics 146 2020:e20201576
[10] https://www.princeton.edu/news/2020/09/30/largest-covid-19-contact-tracing-study-date-finds-children-key-spread-evidence

A description of the transmission chain, as of September 17:

A. In generation 0 (the first cases that were found at the school without a previous known infection source) 11 individuals were discovered. Most of the verified individuals were fifth grade schoolchildren.

B. In generation 1 (transmission from generation 0), 18 individuals were infected. The transmission period ranges from 1 to 6 days (3 days on average).

C. In generation 2 (transmission from generation 1), 20 individuals were infected. The transmission period ranges from 1 to 12 days (5 days on average).

D. In generation 3 (transmission from generation 2), 21 individuals were infected. The transmission period ranges from 2 to 37 days (7 days on average).

E. In generation 4 (transmission from generation 3), 9 individuals were infected. The transmission period ranges from 2 to 17 days (4 days on average).

6. The total number of transmission days from generation 0 to generation 4 ranged from 7 to 23 days (9 days on average).

7. Figure 7A shows the transmission chain by age group.

**Figure 7A. Transmission chain by age groups**
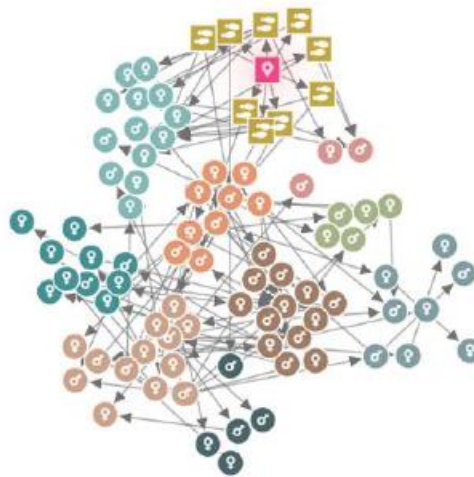
⬤ Generation 0 transmission site   ⬢ Generation 0 exposure event time → Direction of transmission

Age group (and number of verified individuals belonging to it):

(13) 9-12	(5) 5-8	(5) 0-4
(13) 25-34	(10) 18-24	(8) 13-17
(3) 55-64	(13) 45-54	(9) 35-44

8. Figure 7B shows the transmission chain by towns. One can see how transmission passes from the town of Ashdod to Kiryat Malachi, Ashkelon and others.

Figure 7B. Transmission chain by towns

📍 Generation 0 transmission site ⬛ Generation 0 exposure date → Direction of transmission

♂ Male   ♀ Female
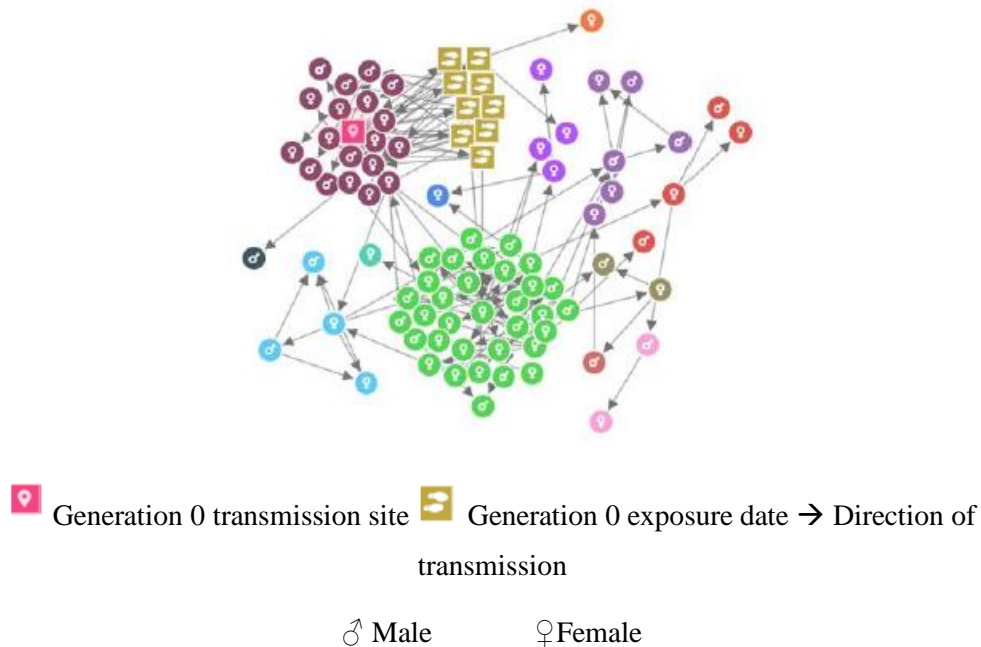
Towns (and number of verified individuals belonging to that town):

Ashkelon (6) ●	Ashdod (20) ●	Kiryat Malachi (33) ●
Orot (4) ●	Ofra (4) ●	Kiryat Gat (4) ●
Rishon le Zion (1) ●	Gedera (2) ●	Efrat (2) ●
Jerusalem (1) ●	Bareket (1) ●	Zarhia (1) ●
		Rehovot (1) ●

9. The transmission chain analysis indicates that the generation creation time (from the previous generation to the next generation of transmitted individuals) is a few days. During this time, additional generations may form.

10. Transmission occurs between different age groups and between different geographical regions.

11. The infection chain example shown in the report reinforces findings that were shown regarding infection both of children and of teaching staff.[11]

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[11] htts://www.themarker.com/news/education/1.9174310

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The effect of opening and closing the education system on the number of verified children

1. To examine the degree of the effect of opening and closing the education systems on child morbidity trends, morbidity trends in different age groups were analyzed over time, divided into five periods:

    A. Before the closing of schools (January 27 – March 15);

    B. The "first wave lockdown" between closing of schools and reopening them in the same school year (March 16 – May 4);

    C. After opening of schools until the end of the 2019-20 school year (May 5 – June 30);

    D. The summer vacation (July 1 – August 31);

    E. Opening of the 2020-21 school year until closing of the schools in the second lockdown (September 1 – October 12).

Figure 8. Percentage of verified individuals aged 0-17 out of the total population
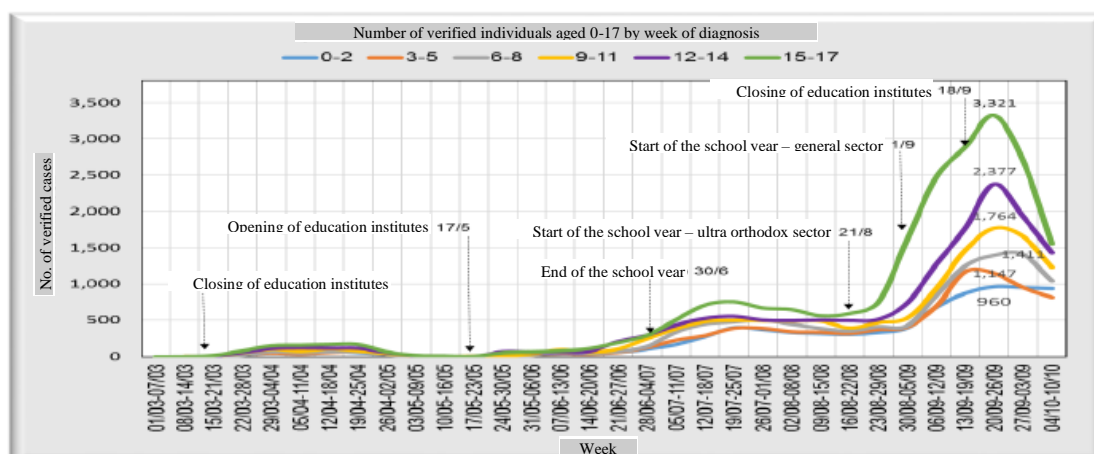
2. Figures 9A-F show the variance in the number of verified individuals on the time axis by age group. All age groups demonstrate an increase upon opening the school year and a decrease after the lockdown started, with the increase being steeper with increasing age.

Figure 9A. Number of verified individuals aged 0-2 on the temporal axis
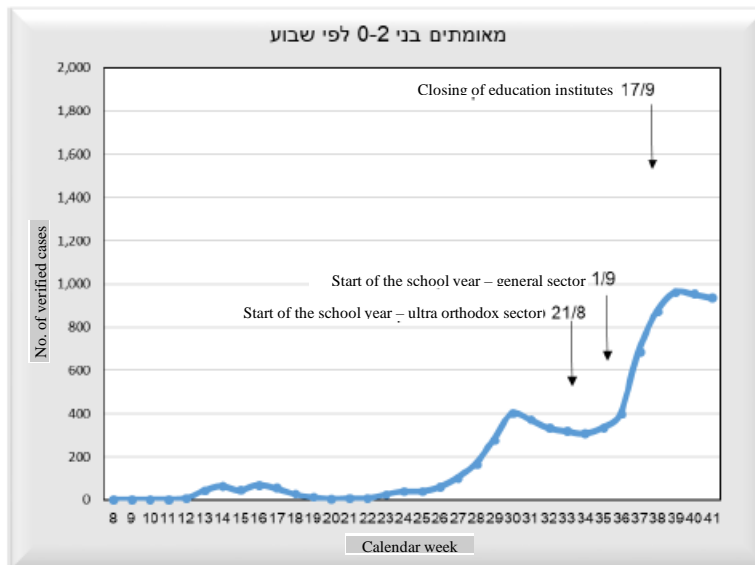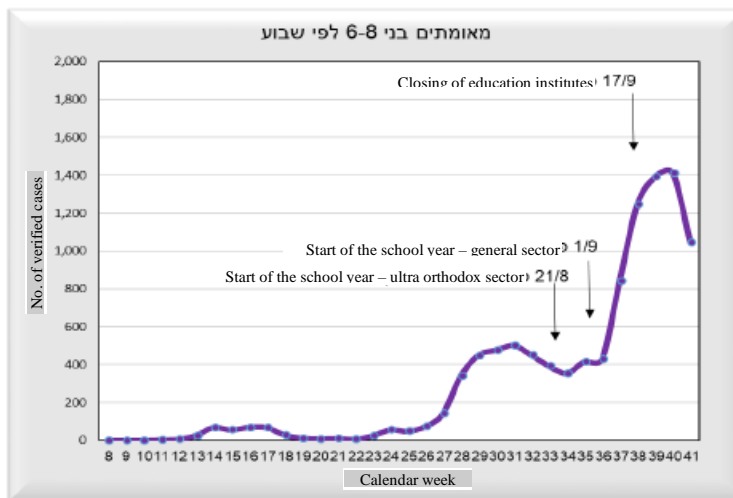
In the 0-2 age group the number of verified individuals increased threefold compared to the mean for the last two weeks before opening of the school year.

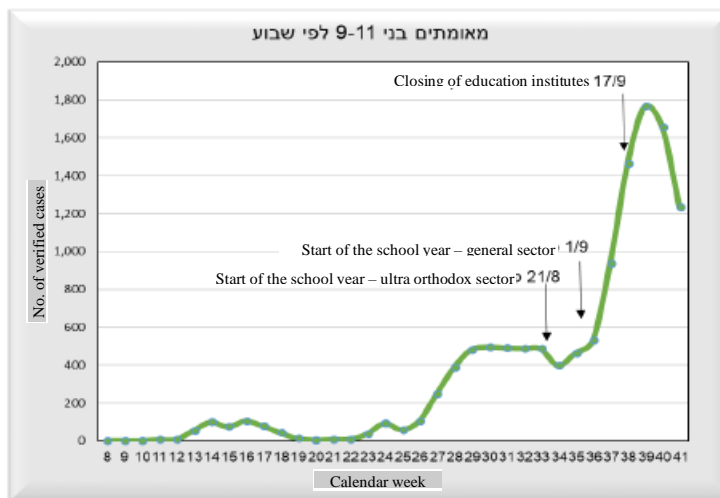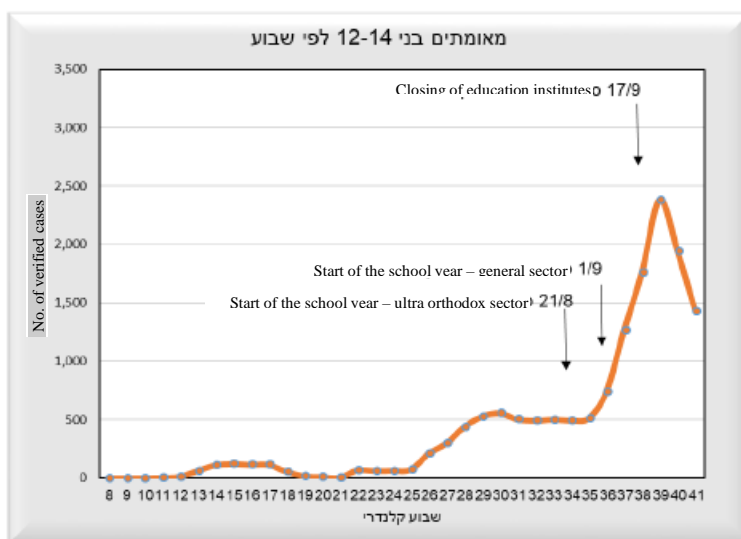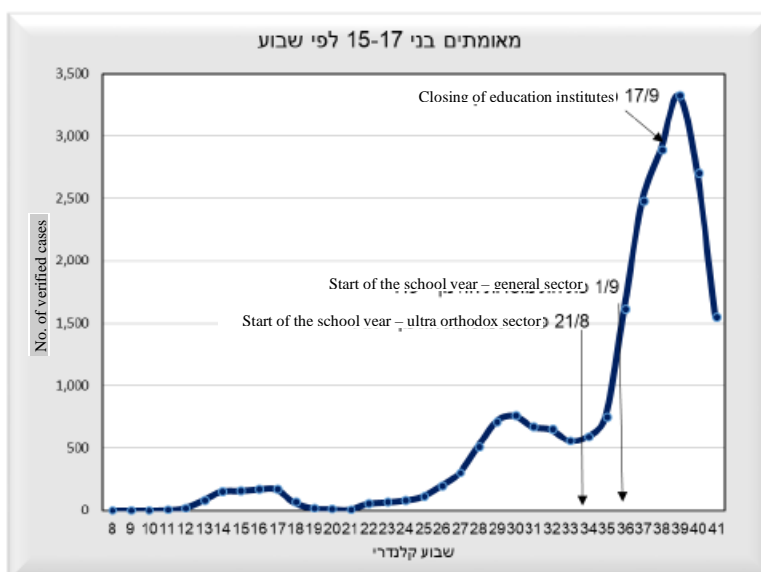**Figure 9B. Number of verified individuals aged 3-5 on the temporal axis**
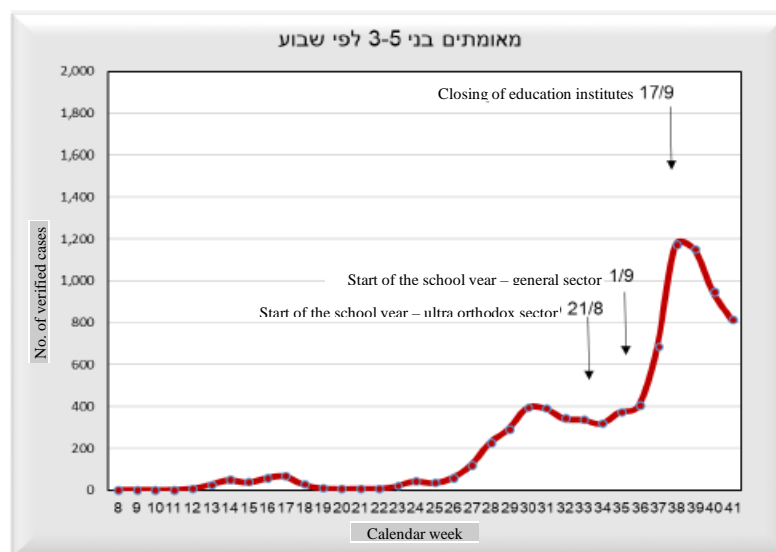
In the 3-5 year age group, the number of verified individuals increased by a factor of 2.9 compared to the mean for the last two weeks before opening of the school year.

14

Figure 9C. Number of verified individuals aged 6-8 on the temporal axis

In the 6-8 year age group, the number of verified individuals increased by a factor of 3.5 compared to the mean for the last two weeks before opening of the school year.

Figure 9D. Number of verified individuals aged 9-11 on the temporal axis

In the 9-11 year age group, the number of verified individuals increased by a factor of 3.6 compared to the mean for the last two weeks before opening of the school year.

15

Figure 9E. Number of verified individuals aged 12-14 on the temporal axis

In the 12-14 year age group, the number of verified individuals increased by a factor of 3.9 compared to the mean for the last two weeks before opening of the school year.

Figure 9F. Number of verified individuals aged 15-17 on the temporal axis

In the 15-17 year age group, the number of verified individuals increased by a factor of 4.5 compared to the mean for the last two weeks before opening of the school year.

3. Figure 10A-B show the variation in number and rate of verified and individuals in isolation among schoolchildren and educational staff. **It may be seen that opening the school year led to an increase and closing of the education system led to a decrease in the rates of positive and schoolchildren and parents in isolation.**

16

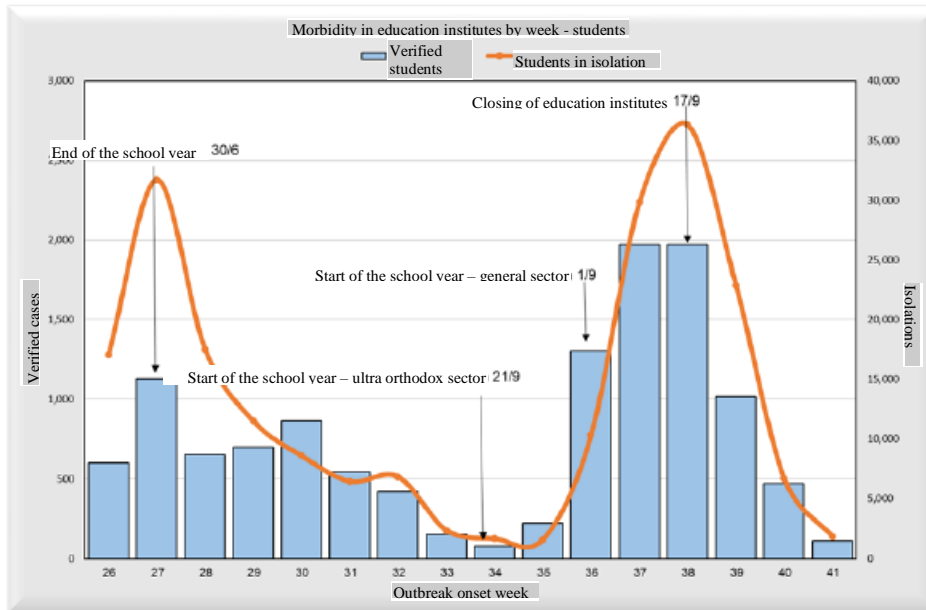**Figure 10A. Morbidity in education institutes by week – students**

Figure 10B. Morbidity in educational institutions by week – staff
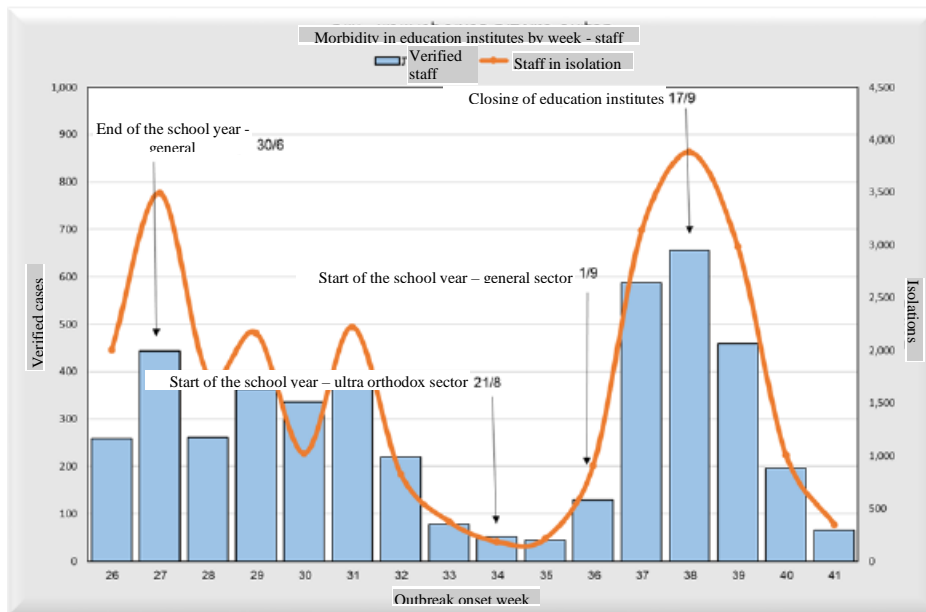
Figure 11. Percentage of change in rate of verified individuals who are children (0-17 years, inclusive) and adults (aged 18+)
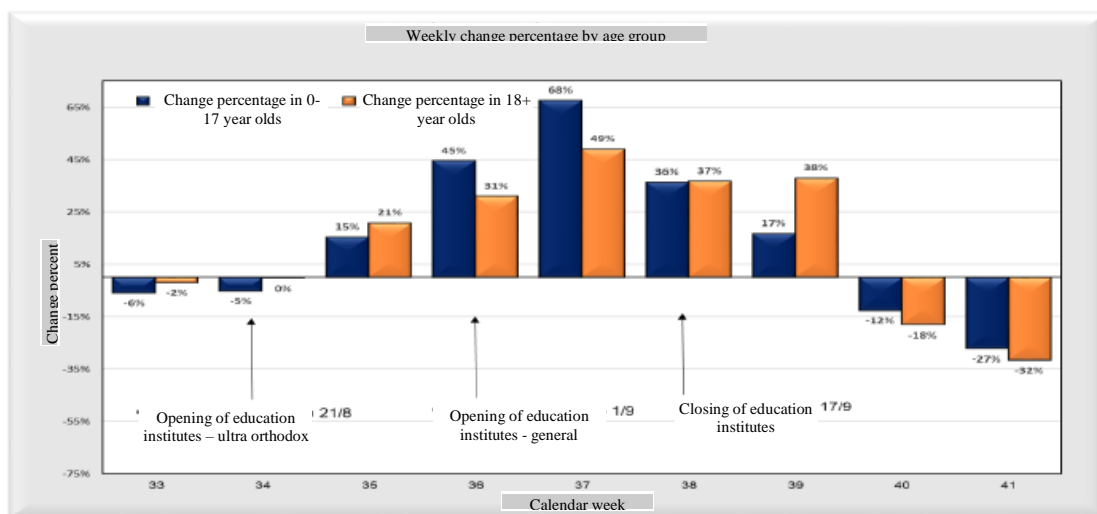

Figure 11 shows how the opening of the year led first to an increase in number of infected children and how its closing led first to a decrease in infected children. Afterward the adults followed this trend.

Summary and conclusions

1. The Ministry of Health is contending with a continuing coronavirus pandemic that requires evaluating the transmission and morbidity level in children and the consequences for the entire population of the country, like other countries.[12]

2. According to the analysis provided here, children are infected and infect and may be super-spreaders. Because most of them present no symptoms, it is difficult to identify a major proportion of children carrying the virus, and they may be a source of infection for others.

3. Child attendance of education settings, particularly in a state of extensive morbidity in time and place, may expedite the spread of disease from place to place and in different age groups, primarily owing to them being a source of transmission among family members at home. The effect may be both in different age groups and in different geographic regions.

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[12] Davies, N.G., Klepa, P., Liu, Y. et al. Age-dependent effects in the transmission and control of COVID-19 epidemics, *Nat Med* 2020; **26**: 1205-121

4. It is important for the education system to resume its activity **gradually and in accordance with the morbidity level** in the different age groups and geographic regions.

Best regards,

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