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ORIGINAL RESEARCH PAPER



Effectiveness of a Hungarian peer education handwashing programme in primary and secondary schools

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ABSTRACT

Purpose: Proper handwashing helps prevent the spread of communicable diseases. The aim of our study was to analyse and compare children's knowledge and skills in hand hygiene before and after school interventions in order to evaluate the effectiveness of our peer education programme. **Materials/methods:** In our longitudinal study, short- and long-term changes in the knowledge, hand-washing skills and health behaviour of 224 lower, upper and secondary school students were assessed. Our measurements were performed with a self-administered, anonymous questionnaire and the Semmelweis Scanner. **Results:** As a result of the intervention, the proportion of correct answers increased significantly both in the short term and in the long run compared to the input measurements, but age differences did not disappear for most variables. There is a difference in the process of learning theoretical knowledge and practical skills. Areas not used for handwashing in the paediatric population are different from those described for adults in the literature. There was no significant difference between the mean scores of the right and left hands. **Conclusions:** There was a significant positive change in both theory and practice of handwashing. In education, emphasis should also be put on long-term retention of theoretical knowledge in age-specific health promotion programmes within the paediatric population.

KEYWORDS

hand-hygiene, handwashing skills, handwashing knowledge, peer education, school intervention

INTRODUCTION

Numerous studies established earlier the associations between handwashing and the prevalence of distinct infections [1, 2]. Person-to-person transmission via hands and contaminated objects plays a key role in the spread of infections [3]. Previous studies investigating the most frequently missed areas in adult population found that right-handed people have more left-sided areas on the dorsal area of the right hand [4–7]. Although handwashing is a simple and efficient method for reducing the risk of communicable diseases, certain viruses and other

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infectious agents, studies have shown the relatively low adherence to the recommended handwashing protocols [8–10].

Several studies conducted worldwide have discussed the problem of general hygiene and handwashing among students [11–13]. In line with this, the important role of handwashing and health education has been highlighted in promoting adequate handwashing, as a relevant contribution to breaking the transmission cycle of distinct infections [14].

Research studies among children showed that students, who followed the appropriate hand-hygiene rules, missed less school hours because of any illness, although many research studies were not well executed or reported [15–18]. Prevention is an effective, simple and cheap method of reducing the prevalence of infections, in which proper handwashing plays a vital role. This conclusion is the most important intellectual heritage of Ignaz Semmelweis (1818–1865) [19]. The earlier education starts in childhood, the more efficient it becomes, so it is recommended to develop children's hygienic behaviour from the first school years on. It is important to note that adoption of a health behaviour and turning it into a habit are predicted by social-cognitive factors, such as attitude, subjective norms and self-efficacy beliefs [20–23].

Because the young, developing children are more likely to get any communicable disease due to their lifestyle and not fully developed immune system, we aimed to develop and test an effective peer-education programme in the field of handwashing [24, 25].

During properly supervised and executed peer education students open up and talk freely and positive behavioural changes can be detected among them [23, 26]. Young generations have “good” opinions about peer education-based health promotion programmes; therefore, these programmes are recommended in these age groups [24, 27]. Through peer education, “lecturers” focus on developing practical skills using interactive tasks considering the receptiveness and learning strategies of the age groups.

The purpose of this study is to analyse and compare children's knowledge and skills in hand hygiene before and after four-lesson peer education programmes in school environment.

MATERIALS AND METHODS

The STAnD (which is an acronym of the following words: Study, Teach, Understand) peer educational programme is a programme of the Hungarian Academy of Sciences with different target issues in health promotion (e.g. fluid consumption, internet addiction, basic life support) [22]. One of the STAnD Programmes is the Hand Washing Programme (SHWP). The aim of the SHWP was (1) to teach 6–18-year-old children in a four-hour-long school health day programme the six-step WHO handwashing technique, which has been proven effective [25, 28] and (2) to develop their health-conscious behaviour relating to hand hygiene.

In the first part of SHWP there was an elective preliminary training course for future peer educator students. In the 24-lesson preparatory courses, which were elective trainings in healthcare and teacher training higher education institutions, the students (1) were able to acquire essential knowledge, innovative, cooperative learning and teaching methods and (2) developed their own active, creative and playful prevention programme plans under tutor control. In the second part of our programme handwashing programmes were delivered to the target population on school health days by teams of four peer educators. We used questionnaire-based and physical measurement-based research methods in the second part of SHWP to measure the effectiveness of the hand hygiene training programmes and the impact of these health promotion interventions [25]. The anonymous, self-administered and – structured questionnaire focused on basic socio-demographic data, self-perceived health status, knowledge and health behaviour in terms of handwashing habits [25]. The physical measurement-based research instrument, the Semmelweis Scanner (by HandinScan Ltd. 2018, Budapest) – a mobile digital and control device was used in our programmes to objectively evaluate the effectiveness of children's handwashing techniques [6, 28, 29]. In the physical measurement-based research 20–20 parts of left and rights hands were examined in every child. The short- and long-term effects of the handwashing techniques were measured by the Semmelweis Scanner and analysed by an expert of our research group at three times: before the intervention (Input) and right after the intervention (Output 1), as well as four months after the intervention (Output 2) [25].

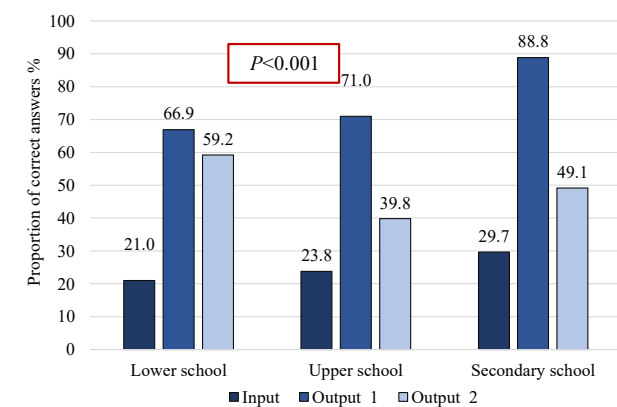
The target population of the SHWP was formed from two primary and two secondary schools. In Hungary, the primary schools are divided in two sections: lower primary school (approx. 6–10-year-old children) and upper primary school (approx. 10–14-year-old children). 464 children took part in our four-lesson school prevention programmes and filled out our questionnaires before the intervention (Input) and right after the intervention (Output 1), as well as four months after the intervention (Output 2), but only 224 children's handwashing techniques were measured by the Semmelweis Scanner. In our present sample 42.9% ($n = 199$) of the participants were boys and 56.9% girls ($n = 264$). Half of the students were from primary and the other half from secondary schools (Table 1).

For statistical analyses, we used the IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp. Released 2017, Armonk, NY: IBM Corp.). When evaluating questionnaires, differences in proportions of the correct answers between measurement times were evaluated using two-tailed McNemar's test stratified on the age groups (i.e. school levels). When analysing hand scanning results, the rate of error on the most frequently missed areas according to the literature was calculated for each individual as the number of error points in the areas known to be the most frequently missed ones (the thumb, the near-thumb area and the fingertips on the dorsal part of the right hand) per the number of all error points. The relationship between the rate of error



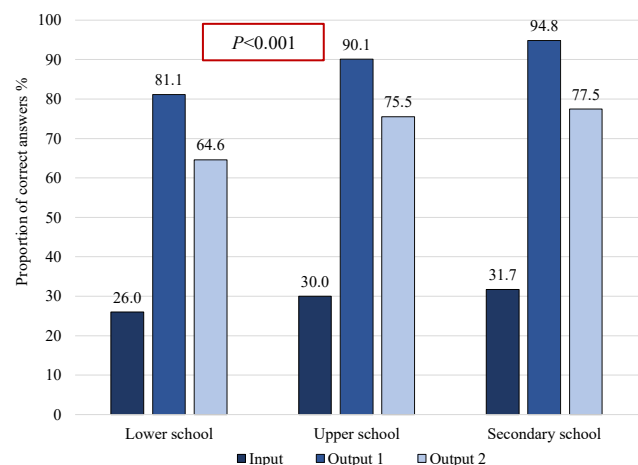
Table 1. Division of the sample of SHWP in the different school types by research method and sex (per person and rate; $N = 464$)

Characteristics of sample		Types of school					
		Lower primary school		Upper primary school		Secondary school	
		Per person	Rate in sub-samples (%)	Per person	Rate in sub-sample (%)	Per person	Rate in sub-sample (%)
Research methods	Filling questionnaires	128	100.0	103	100.0	233	100.0
	Measurement by Semmelweis Scanner	128	100.0	102	99.0	99	42.4
Sex	Male	60	46.9	40	39.2	99	42.5
	Female	68	53.1	62	60.8	134	57.5



"What kind of soap should be used in everyday life?" (Proportion of correct answers %, $n = 458$)

Fig. 1. Children's soap choice for daily use



"Which hand-drying method is the most sufficient regarding the cleanliness of the hand?" (Proportion of correct answers %, $n = 460$)

Fig. 2. The most sufficient hand-drying method

on the most frequently missed areas and theoretical knowledge (i.e. whether an individual knows which are the most frequently missed areas or not), gender and age were evaluated using simple linear regression models. Throughout the analysis, $P < 0.05$ was considered to indicate statistical significance.

RESULTS

Knowledge and health behaviour regarding handwashing before and after the intervention

At Input, the proportion of the correct answers regarding the question about using the proper soap (*What kind of soap should be used in everyday life? Bar soap/Scented soap/Antiseptic soap/Liquid soap*) – *Liquid soap* being the correct answer – was 21.0% at lower primary school, 23.8% in upper primary school and 29.7% in secondary school (Fig. 1). At Output 1, the proportion of the correct answers increased in every age group (66.9%, 71.0% and 88.8%; two-tailed exact McNemar's test $P < 0.001$ in all age groups). At Output 2, the proportion of the correct answers decreased compared to Output 1 (59.2%, 39.8% and 49.1%), but were still higher than before SHWP ($P < 0.001$ and $P < 0.010$, respectively). We would like to highlight that the most popular wrong answer regarding the question about the proper soap was

antiseptic soap in all the three age groups (68.5%, 71.3% and 61.6%). Thanks to the peer education programme we were able to correct this popular misconception.

The proportion of the correct answers regarding the healthiest option, (*Which hand-drying method is the most sufficient regarding the cleanliness of the hand? Electronic hand dryer/Towel/Paper towel/My clothes if they're clean*) paper towel was chosen correctly in 26.0% in lower primary school, 30.0% in upper primary school and 31.7% in secondary school at Input (Fig. 2). At Output 1 the percentages increased to 81.1%, 90.1% and 94.8%, and these differences were significant compared to the Input measurement at every school level ($P < 0.001$ in all age groups). Participants' knowledge decreased at Output 2 (64.6%, 75.5% and 77.5%), although these percentages were higher compared to the Input measurement ($P < 0.001$ in all age groups).

At Input the proportion of correct answers (i.e. between 20 and 30 min) regarding the proper length of handwashing (*For how long do we have to count during the sufficient handwashing? We have to count at least when we wash our hands carefully.*) was 34.7% among lower primary school students, 29.6% in the upper primary school and 36.1% in the secondary school group. At Output 1 the percentages increased at every school level (79.2%, 87.3% and 88.0%, $P < 0.001$ in all age groups). At Output 2 this

knowledge decreased to 55.9%, 65.1% and 68.4%, although these percentages were still higher compared to the Input measurement ($P < 0.001$ in all age groups).

Since the changes of health behaviour (*For how long do you usually wash your hands? I count at least to 3 during handwashing/I count at least to 10 during handwashing/I count at least to 20 during handwashing/I count at least to 60*) could be detected only in the long run, that is why the results of health behaviour questions were compared only at Input and Output 2 measurements. Before the handwashing programme 48.0% of lower primary school students washed their hands for at least 20 sec based on self-assessment. This proportion was only 25.0% among upper primary school students and 26.4% in the group of secondary school students. At Output 2 these values grew to 58.4%, 45.6% and 35.3%; however, the differences between the two time points were significant only in case of the upper primary school and secondary school students ($P < 0.001$ and $P = 0.014$, respectively).

About washing hands after visiting a sick person (*Do you usually wash your hands after visiting a sick person? Yes/No*), most of the students had positive health behaviour even at Input. 92.1% of the participants from lower primary school, 91.8% from upper primary school and 88.3% from secondary school usually wash their hands after visiting a sick person. At Output 2, the proportion of the correct answers remained the same in the case of lower primary school participants, it decreased to 89.3% among upper primary school students (the difference was not significant; $P = 0.79$), while it increased to 94.0% in the group of secondary school students ($P = 0.019$).

Handwashing before toilet usage (*Do you usually wash your hands before using the toilet? Yes/No*) was the least evident among the participants. At Input, the proportion of those who wash their hands before using the toilet was 22.8% in the case of lower primary school students, 12.9% among upper primary school students and 15.9% in the secondary school group. At Output 2 the percentages increased in every age group (40.3%, 37.3% and 17.6%); however, the differences between the two time points were significant only in case of the lower primary school and upper primary school students ($P < 0.001$ in both cases).

Handwashing skills

Before presenting the hand scanning results, we have to note that 91.0% of our sample was right-handed and 9% was left-handed. The average error point measured during manual scanning of the total 20 error points were 2.46 ($SD = 2.46$) on the right hand and 2.16 ($SD = 2.31$) on the left hand.

Examination of frequently missed areas – as reported in previous literature – in our sample. In our study of the children population, we looked at frequently missed areas found in adults in previous studies (See in Introduction) such as the thumb, the near-thumb area and the fingertips on the dorsal part of the right hand. 197 students who made at least one mistake during the Input hand scan were

Table 2. Number of all errors in different parts and areas of the hand during the Input hand scan measurement (per person; $N = 224$)

Area	Left dorsum	Right dorsum	Left palm	Right palm
Fingertips	74	81	0	0
Thumb	124	135	1	0
Index finger	48	43	0	1
Middle finger	32	38	0	1
Ring finger	34	41	0	1
Little finger	49	56	1	1
Medial dorsum	31	31	0	0
Distal dorsum	27	38	0	1
Lateral dorsum	33	46	0	0
Proximal dorsum	29	38	0	0

examined. In 60.40% ($n = 119$) of these students at least half of the mistakes were found in the most frequently missed areas in adult population (See in Introduction). Furthermore, it could also be observed that 30.46% of the students ($n = 197$) had error points only in the areas in question.

Based on the cumulative error rates of the 40 regions of the hand, we examined how many students made errors in each area with the help of hand scanning. A large number of error points were observed at the thumb and fingertips, which is in accordance with the literature, but in the study population lateral dorsum was overtaken by little finger on both the right and left dorsal areas. The back of the index finger on the left hand was also ahead of lateral dorsum. The number of error points on both palms is negligible (Table 2).

Factors influencing Input hand scanning in the most frequently missed areas. Next, we aimed at investigating whether certain factors influenced the high error rate in the most frequently missed areas observed at the Input hand scanning measurements. Therefore, error rates of Input hand scanning have been examined from the aspects of theoretical knowledge (i.e. whether a student knows which are the most frequently missed areas or not), gender and age. First, we calculated the *rate of error on the most frequently missed areas* for each individual as the number of error points in the areas known to be the most frequently missed ones (the thumb, the near-thumb area and the fingertips on the dorsal part of the right hand) per the number of all error points. Next, we evaluated the relationship between the rate of error on the most frequently missed areas and theoretical knowledge, gender and age using simple linear regression models. No significant association was found between the rate of error on the most frequently missed areas and theoretical knowledge ($F(1,195) = 0.01$, $P = 0.920$, coefficient = 0.00; CI (95%): -0.09 to 0.08). Therefore, it cannot be stated that those who knew them were less likely to make mistakes in the given areas.

Similarly, the gender of the students did not significantly influence the rate of error on the most frequently missed areas ($F(1,195) = 0.37$, $P = 0.546$, coefficient = 0.03; CI (95%): -0.06 to 0.11).



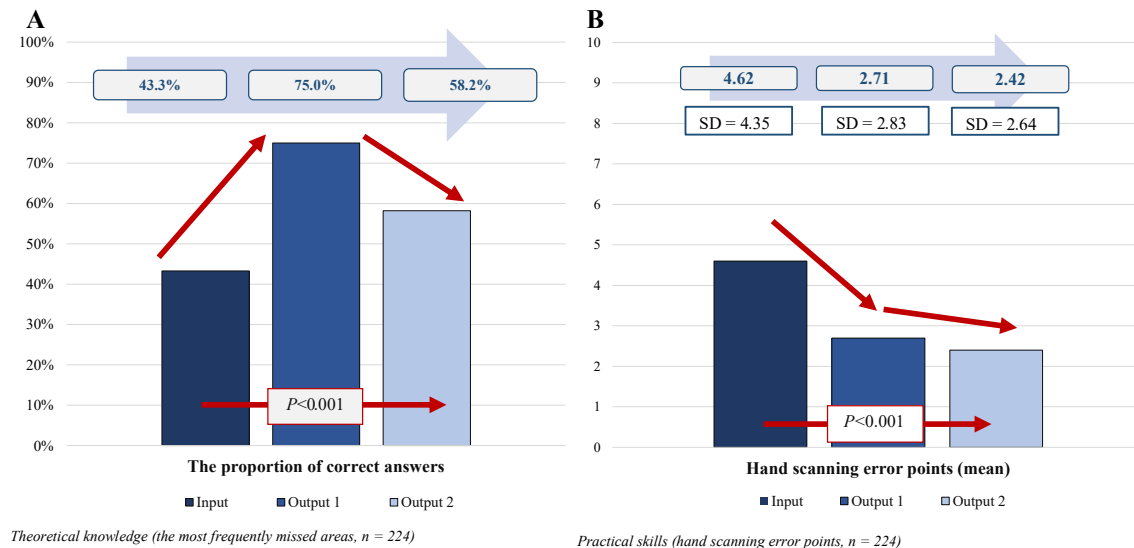


Fig. 3. Comparison of theoretical knowledge and practical skills. (A) The proportion of correct answers. (B) Hand scanning error points (mean)

Age, on the other hand, significantly influenced the rate of error on the most frequently missed areas ($F(1,195) = 4.57$, $P = 0.033$, $R^2 = 0.023$), as each year of life increased the error rate by 0.02, suggesting that as the age grows it is increasingly more common for students to make mistakes in the areas characteristic in adults (coefficient = 0.02; CI (95%): -0.00 to 0.03).

The multivariate regression model (i.e. including all three variables) was not significant ($F(3,193) = 1.65$, $P = 0.180$).

Improvement of theoretical knowledge over time

Theoretical knowledge was examined on the basis of the most frequently missed hand areas (Fig. 3A). At the time of the Input measurement, 43.3% of the students was aware of the correct answer, which number increased to three quarters of the students by the assessment at Output 1, and the difference was highly significant (two-tailed exact McNemar's test $P < 0.001$). At Output 2, the rate of correct answers dropped to 58.2%, but still reached a higher level than before the programme ($P < 0.001$).

Improvement of practical skills over time. Practical skills were tested on the basis of mean errors in hand scanning (Fig. 3B). A repeated measure of ANOVA with a Greenhouse–Geisser correction determined that the mean errors of hand scanning differed statistically significantly between the three time points ($F(1.17, 379.03) = 32.360$, $P < 0.001$). Post hoc tests using the Bonferroni correction revealed that SHWP resulted in a significant reduction of mean errors in hand scanning from Input to Output 1 (4.62 ± 4.35 error points vs. 2.71 ± 2.83 error points, respectively), which was statistically significant ($P < 0.001$). Moreover, at Output 2, the mean error points reduced further to 2.42 ± 2.64 points, which was

statistically significantly different from Input ($P < 0.001$), but not from Output 1 ($P = 0.613$).

DISCUSSION

According to the literature on adults, right-handed people have more areas left-out on the right dorsum [4, 5]; however, in our study population, no difference was found between right- and left-hand scans before the intervention. Theoretical knowledge and practical skills were improved at Output 1 compared to the Input outcomes. At output 2, there is a decline in theoretical knowledge – although the results are still better than the Input scores – while hand-washing skills have clearly improved. Interactive skills development, considering the age of the children, has proved to be truly effective in the long run; the theory transfer tasks have also improved, but to a lesser extent.

When examining the missed areas, considering the literature [4–7, 19] it can be seen that most of the students' missed areas are only partially identical to the areas missed by adults. The area around the thumb is less properly washed, but new unwashed regions (i.e. not common in adults) appear on the fingers, indicating that children may have different habits. Looking at age, it can be observed that as age progresses the areas skipped by children over the course of their lives are increasingly aligned with those skipped by adults.

In the case of the soap used in everyday life, the values for correct knowledge were surprisingly low and no significant difference could be detected between the different age groups. Prior to the intervention, the rate of incorrect responses was high. Most have labelled antiseptic soap as the right choice for everyday handwashing, while it can damage the skin microbiota, so should be used only when warranted.

Following the intervention, the proportion of correct answers became statistically much higher.

On the questions of the most appropriate hand wiping method [30, 31] at Input less than half of the students knew that paper towels were recommended. Among the other options (electric hand dryer, private linen, cloth towels), the answers were divided, indicating that only a small proportion of students had sufficient knowledge on the subject matter.

According to the World Health Organization, after a patient visit, handwashing is necessary for preventive purposes [28]. Most students were aware of this information and acted accordingly. Publications about hospital hand hygiene may have had a positive impact on this form of student health behaviour.

Handwashing before using the toilet showed a low frequency. A small percentage of students said they wash their hands before going to the bathroom. In the long run, this health behaviour was also positively influenced, doubling in the lower primary school groups, increasing significantly in the upper primary school groups, and having little influence in this regard in secondary school. However, the majority of students still do not follow good health behaviours [28].

To sum up, although the lower primary school students did not answer the theoretical questions in the highest proportion, in practice they still wash their hands mostly as they self-declare. According to the ECDC statement, 20 seconds is sufficient to carry out a proper hand hygiene routine [31]. Due to the time needed to record the change in behaviour, we compared our data only to the Output 2 questionnaires. At Output 2, although the proportion with regards to the length of handwashing increased in all age groups, it was still below expectations.

At Input and Output 1, lower primary school students are washing hands for even a higher amount of time than they know it would be adequate to maintain health. There was no such correlation between upper primary and secondary school students.

CONCLUSIONS

There are differences in the hand hygiene skills of child and adult populations, which needs to be taken into consideration when designing age-specific health promotion programmes.

The peer education programme proved to be effective because we could see an improving trend in both theoretical and practical skills following the programme. Although at Output 2 theoretical knowledge decreased, the practical skills improved slightly.

In the case of programmes aimed at developing practical skills, it must be taken into consideration that in order to improve and maintain good practices in the long term, integrating theoretical and practical knowledge into the curriculum would be beneficial.

As for their health behaviour, students tend to miss significant handwashing occasions in their daily practice. These are worth paying close attention to and informing educational institutions and their teachers should be continued.

Ethical approval: Our research is morally acceptable and we follow the World Medical Association's Declaration of Helsinki and requirements of all applicable local and international standards. The Hungarian Medical Research Council Research Ethics Committee approved this research (No 18241-2/2017/EKU).

Authors' contribution: ZZM: data collecting procedure, data entry, statistical analysis of knowledge data, writing some parts of sections. LV: data collecting procedure, data entry, statistical analysis of handwashing skill data, writing some parts of sections. GGY: data collecting procedure, data entry, statistical analysis, writing some parts of sections. ÁL: data collecting procedure, data entry, evaluate of scanner data, checking of the manuscript. EG: finding references; complement of Introduction section, checking of the manuscript. ÁLJ: complement of Results section, checking of the manuscript. RF: data collecting procedure, references, checking of the manuscript. AG: statistical analysis, checking of the manuscript. AF: complement of Results, Discussion and Conclusion sections, checking of the manuscript. HJF: data collecting procedure, complementing Materials and methods; checking of the manuscript; coordination of authors' contributions.

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