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Short Communication

Effect of chlorine dioxide gas of extremely low concentration on absenteeism of schoolchildren

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Gas-generating devices of chlorine dioxide (ClO_2) are used as deodorant of rooms. We happened to use a commercial tabletop deodorant canister that releases extremely low-concentration ClO_2 gas in a school classroom as deodorant. We found retrospectively and unexpectedly that during a period of 38 consecutive school days the rate of school children absent from the school was markedly lower (1.5%) in a classroom where the ClO_2 device was placed than that (4.0%) in a classroom where it was not placed. The percentages of absenteeism between these classrooms (1.5% vs. 4.0%) were significantly ($p < 0.00001$) different. The predominant causes of absenteeism during the period were common cold and influenza. Judging from the known virucidal activity of ClO_2, our unexpected finding in the school classrooms strongly suggests the usefulness of extremely low-concentration ClO_2 gas to prevent respiratory viral diseases in semi-closed areas, such as theaters, hospitals and aircraft, without necessitating evacuation.

Key words: Chlorine dioxide, absenteeism, schoolchildren, gas, influenza, respiratory infection, virus.

INTRODUCTION

Chorine dioxide (ClO_2) is water-soluble gas at room temperature (Gordon et al., 1972). It has long been used as a disinfectant of tap water (Betancourt and Rose, 2004), bleach (Moran et al., 1953) and deodorant (Loesche and Kazor, 2002). Owing to its strong oxidizing activity, it inactivates bacteria, fungi and viruses (Berg et al., 1982; Morino et al., 2007; Roller et al., 1980; Simonet and Gantzer, 2006). ClO_2 gas released from its aqueous solution has been used as a sanitizer and a deodorant of room air. We used a commercial tabletop deodorant ClO_2 gas-generating device in school classrooms, and noticed an important finding about the absenteeism of school-children. The emerging threat of an influenza pandemic that may be spread rapidly by air travel is currently a serious global concern. The importance of our finding in terms of prevention of the spread of respiratory viral dise-ases, such as high-virulence avian influenza, in semi-closed areas, such as theaters, hospitals and aircraft, is briefly discussed.

MATERIALS AND METHODS

A commercially available tabletop ClO_2 gas-generating device (Cleverin G, a canister of 150 g active ingredients) was used. The ingredients of the device are sodium chlorite ($NaClO_2$), sodium dihydrogenphosphate (NaH_2PO_4), sodium salt of polyacrylic acid and water. The device releases gaseous ClO_2 in a sustained manner. Three of these devices were placed in a classroom with 65-m^2 floor area (230-m^3 volume) and 34 schoolchildren for use as a deodorant. According to the manufacturer, the concentration of ClO_2 becomes 0.01-0.03 ppm in a classroom of this volume when that number of units is used. The data were collected from an elementary school with schoolchildren of 6-12 years old and with almost equal numbers of girls and boys. The statistical evaluation of the difference in the rate of absenteeism between two groups (schoolchildren in classrooms with or without the ClO_2 devices) was done by a χ^2 test, and the difference was considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

When we used the device in a school classroom, we found retrospectively during the period of 38 consecutive school days that the rate of absenteeism (number of absent schoolchildren divided by a nominal number of school children in that particular classroom) during the period of 38 consecutive school days (from January to March) appeared lower in the classroom where the ClO_2 devices were placed compared to that in the classrooms where such devices were not placed (Figure 1). However, it was statistically unclear from Figure 1 whether the

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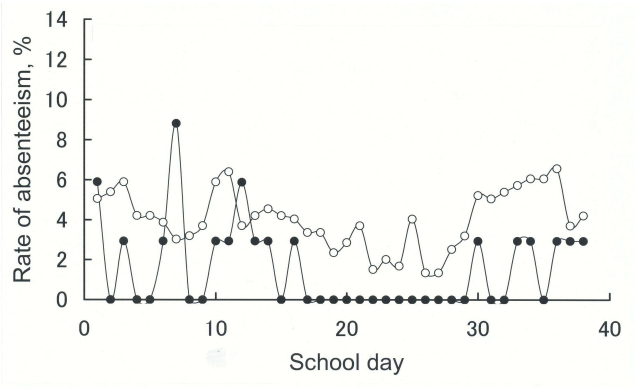

Figure 1. Rates of absenteeism of school children. Rates of absenteeism (number of absent schoolchildren divided by a nominal number of school children in that particular classroom) in classrooms where ClO_2 gas-generating devices (Cleverin G) were (filled circles, one classroom) or were not (open circles, 17 classrooms) placed are shown.

Table 1. Cumulative numbers of schoolchildren present or absent from school.

Cumulative no. of school children		
ClO_2 device	Present	Absent
Placed	1272 (98.5%)	20 (1.5%*)
Not placed	21634 (96.0%)	900 (4.0%*)

Numbers represent cumulative numbers of schoolchildren in classrooms with (one classroom) or without (17 classrooms) ClO_2 devices who were present or absent from school during 38 consecutive school days. *Significantly different ($p < 0.00001$, χ^2 test).

difference in the rate of absenteeism between the two groups was significant. Therefore, we calculated cumulative numbers of schoolchildren present or absent from school based upon the above data by summing up the daily number of schoolchildren present or absent for the entire 38 school days (Table 1).

The rate of absenteeism demonstrated by the cumulative number of schoolchildren absent from school was markedly lower in the classroom where the ClO_2 device was placed than that in the classrooms without the device. In the former classroom, the cumulative number of schoolchildren present was 1272 (98.5%), and that of schoolchildren absent was 20 (1.5%). On the other hand, in the latter classrooms, the cumulative number of schoolchildren present was 21634 (96.0%), and that of schoolchildren absent was 900 (4.0%). The percentages of absenteeism (1.5 vs. 4.0%) were significantly ($p < 0.00001$, χ^2 test) different. This unexpected observation strongly suggests usefulness of the device in preventing infectious, most probably respiratory, diseases in a community. To rigorously prove the effect of low-concentration ClO_2 gas against the occurrence of diseases, it will be needed in a future study to do a crossover study, in which a classroom where a ClO_2 device was placed is studied again without the device with the same population of children.

The effect of the device on the lower rate of absenteeism appears to be due to the ClO_2 gas released from the device, since the only volatile materials released from the device are ClO_2 and water. Respiratory viral diseases, such as high-virulence avian influenza, are major public health concerns worldwide (Ginsberg et al., 2009). Due to the potential for rapid spread of such diseases via air travel, they could immediately result in pandemics with millions of fatalities. However, at present there are almost no effective countermeasures against such devastating infectious diseases in semi-closed areas, such as aircraft, tramcars and school classrooms. Judging from the known virucidal activity of ClO_2 (Zoni et al., 2007), our unexpected and retrospectively observed finding in school suggests the possible usefulness of extremely low-concentration ClO_2 gas to prevent the spread of respiratory viral diseases without necessitating evacuation. Based upon the serendipitous observation in a school, we conclude that ClO_2 gas at an extremely low concentration could potentially prevent diseases, such as respiratory infections, in semi-closed areas. Large-scale prospective studies based upon a solid methodology would be needed to substantiate our important observation.

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