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Differences Between the Terms Antibacterial, Antisepsis, Disinfection, Pasteurization, and Sterilization and the COVID-19 Preventive Effect of Equipment Used for These Purposes

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ABSTRACT

To prevent coronavirus disease-2019 (COVID-19), many types of equipment, such as instruments and devices, effective in eliminating microorganisms, have been developed and sold in Japan. However, some of them were not effective enough. For instance, the terms, such as antibacterial, antisepsis, disinfection, pasteurization, and sterilization differ in the type of target microorganisms and the effect they exert. Moreover, not all of them are effective against COVID-19. The meaning of whether the effect is guaranteed also differs by law. In this study, we aimed to clarify the terms related to the prevention of these infectious diseases, and then discuss the differences. Furthermore, we present the results of our investigation and our opinion on whether these methods are effective for the prevention of COVID-19.

INTRODUCTION:

Even until early 2021, the novel corona virus disease-2019 (COVID-19) is still prevalent worldwide, and there is no exception in Japan. At the end of March 2021, 130 million people were infected, and 2.8 million people died worldwide, including 470,000 and 9,000 people in Japan, respectively. To prevent COVID-19, there is much equipment, such as instruments and devices, used for sterilization were being developed and sold in Japan[1-4]. Unfortunately, many of them did not exert the expected effect (it is important to take into consideration that there was some effect). First, the differences in the terms, such as disinfection, elimination, and sterilization are based on the type of target microorganisms and their effects[5]. This does not simply indicate the strength of the effect, but also the meaning of whether the effect is guaranteed by law. Consumers often think that all products claimed to exert these effects significantly reduce the risk of infection (in other words, the effect of the virus is considered to be almost eliminated). Therefore, if the definition of the term is well-understood, some products may not be considered suitable for the prevention of COVID-19. Additionally, if the products are properly verified by the national government and public organizations, it is possible that ineffective (non-compliance with the definition) products will not reach the market in the first place.

In this study, we first clarify the extent to which each of the terms considered to be related to the prevention of infectious diseases is defined or guaranteed by law. We then discuss the differences in the literal meaning of the terms, such as antibacterial and disinfection, and further describe the results of our investigation into whether they can or cannot be used for the prevention of COVID-19 and our opinion.

Differences in the definition of the terms, such as disinfection and sterilization

Table 1 provides an overview of the differences in several terms[5-9]. Among antibacterial, antisepsis, disinfection, pasteurization, and sterilization, only antibacterial corresponds to the pretreatment and it is further clarified that the objects subjected to antibacterial treatment only do not get infected with the microorganisms. The other four involves the killing or elimination of the microorganisms. Only the antibacterial agents do not target viruses. However, the sterilization process targets all microorganisms, whereas disinfection and others target only a subset of microorganisms. Products that have antibacterial and disinfection effects are miscellaneous goods[2], and their effects are not guaranteed by law. Even the agents

for whom the effects are guaranteed by law, such as antiseptic and pasteurization, do not remove almost all microorganisms, but only guarantee that even a small part of them has the minimum effect. Sterilization exerts a strong effect, and the elimination of almost 100% of microorganisms is guaranteed in this case[5), 6)]. Antisepsis alone does not include killing microorganisms but refers to the action of only targeting the pathogenic microorganisms and attenuating their pathogen city via inactivation. However, sterilization is highly effective in preventing COVID-19, and antibacterial agents are completely ineffective.

Table 2 lists the types of sterilization methods[10)]. The type of material is limited by the type of method used. It cannot be used when the method involves any alteration of the treated material. Some methods are used for special and expensive equipment and chemicals that are difficult for the general public to obtain, so they can only be used by schools, medical institutions, equipment manufacturers, *etc.*, and are not available to everyone. In Table 1, the flame, boiling, and chemical methods are relatively easy to use, even for the general public. The UV method can also be conducted by the general public if UV lamps are available and can be used properly. Many sterilization methods are so powerful that they can only be used to sterilize the surgical and experimental tools and other instruments before and after use, rather than implementing on human skin, the entire interior of a room, *etc*.

Figure 1 shows the examples of the antibacterial spectrum of a disinfectant[6)]. The antibacterial spectrum is a range of susceptible microorganisms exhibiting a growth inhibitory effect and is usually used to select a therapeutic agent with a bactericidal effect on the microorganisms based on the spectrum. Figure 1 also indicates the drugs that were classified into the three categories. High-level disinfectants exert corrosive and inflammatory effects on the human skin. For this reason, it is often used for cleaning the surface of instruments and disinfection through immersing biological samples (feces and vomit) containing pathogens. Among the medium-level disinfectants, hypochlorite irritates the skin and cannot be implemented on the human body. However, iodine and alcohol can be used to clean the skin. Low-level disinfectants can also be used on the skin, but their effectiveness is limited, and the disinfection is considered weak. It should be noted that this information does not include usage and concentration. However, it is discussed in the next section.

Bactericidal affects using commercially available alcohol-based products

Alcohol (ethanol) not only passes through the biological membranes but also exerts an amphipathic effect at concentrations of 40% or more, thereby denaturing cell membrane and proteins[11]. Denaturation breaks down the cell membrane of microorganisms, thereby leading to the formation of holes, and leaking cell contents (so-called lysis). That is, in the presence of water to some extent (when alcohol is diluted with intracellular fluid, etc., or if alcohol is diluted to a low concentration before use), alcohol denatures the cell membrane, and the permeated alcohol increases the internal pressure in the bacterium, thereby leading to cell lysis. High concentrations of alcohol also cause dehydration of the structural water of proteins, resulting in a stronger denaturing effect[11]. Normally, in the case of ethanol, 55% (w/w) or more can be expected to exert a bactericidal effect on various microorganisms (note that not all bacterial species). Previously, it was considered that 70% alcohol exerted the highest bactericidal activity. However, at a concentration of 80% or more, its bactericidal activity decreases. This implies that if the concentration of alcohol is too low or too high, there is no effect. It has been reported that COVID-19 can be sufficiently inactivated upon contact with 50% or more alcohol for one minute[11].

It has been reported that the effect is not consistent when hand disinfection is performed through rubbing alcohol preparations (containing 70% alcohol) [12]. The reason may be that the amount of drug used differs from person to person, and also the method of rubbing differs. Furthermore, the disinfection effect of wet wipes is often considered as less than 50%, which is again not very effective[13]. However, among them, the alcohol-based wipes tend to exert a slightly higher disinfection effect. We believe that this is because the main mechanism of action is the elimination of microorganisms through wiping with paper. The previous value is for single-use, and if you wipe the surface several times, the efficiency will increase.

Effect of spatial disinfection products on COVID-19

Here, we describe the equipment and air purifiers currently introduced in the market in Japan that are publicized as exerting a spatial disinfection effect. These are aimed at reducing the novel corona virus in the air and are currently widely distributed in Japan[1-4]. Most of the former equipment was based on the principle of sterilizing microorganisms, such as viruses through volatilizing chlorine dioxide gas or hypochlorous acid mist into the atmosphere[3].

Chlorine dioxide is thought to exert a similar effect to that of hypochlorite[14]. It is a molecule containing chlorine atoms, and its application may lead to the denaturation of surface proteins of microorganisms, such as bacteria, which is expected owing to its oxidizing power. It can be used by hanging a gas-generating device around the neck like a necklace or by placing it indoors. When a component penetrates through a microorganism, it leads to nucleic acid cleavage and is considered to reduce the infectivity. Considering that chlorine dioxide is similar to hypochlorous acid, it is easy to predict that volatilizing it in the air at a high concentration may irritate the skin and mucous membranes of the eyes[15]. According to the results of investigating the concentration of chlorine dioxide to be volatilized in the air in a previous research study, it is reported that extremely low (less than 30 ppb) concentration should be used, and thus, the bactericidal effect cannot be expected. Current findings suggest that certain conditions are effective in eliminating the virus[15]. However, since the conditions are biased[4), 14], it has not been confirmed whether the actual product is effective. Conversely, hypochlorous acid is an acidic molecule, whereas NaOCl is a neutral salt. Special equipment for volatilizing this in the air is also being sold, but since it is an acidic substance, there is a high possibility that the corrosion of the surrounding metal products may become a problem[14]. Spray formulations are also available; however, they are not drugs. Cases of lung inflammation caused due to the inhalation of excessive spray to prevent COVID-19 have been recognized not only in Japan but also overseas. Unfortunately, using it at a concentration high enough to obtain high efficiency causes adverse effects on the lungs. If you try to suppress these effects, there is almost no effect for preventing infectious diseases, and in the end, it is used as either a spell or decoration[3].

There are also “plasma clusters” and “Nano-e” that are being installed in the electrical air purifiers[1]. These are mainly developed by two Japanese electronics manufacturers and are attached to their products, such as air purifiers. The basic principle of the plasma cluster is to release ions created by the plasma discharge into the room. The released ions can be expected to suppress the mold floating in the room and to remove viruses and deodorizing[1]. Unfortunately, the only thing that some consumers who have purchased realize is that they exert a deodorant effect. The reason for this is that the general public cannot perform microbiological tests, and thus, there is no way to check the amount of virus in the air. Therefore, it has not been proven that mold growth and virus elimination can be achieved, and it is currently considered as a product based on pseudo-science[2]. The effect may be proven later, but we feel uncomfortable that the distributor itself does not indicate such data.

Nano-e is the nano-sized fine particle ions that are generated through applying a high voltage to the moisture in the air. These ions are supposed to be effective for disinfection and virus attenuation, as well as for beautiful skin and hair. It is similar to the plasma cluster, but the difference is in the means and usage of generating ions[1]. It also explains that it damages the microorganisms, even though it does not damage the skin and hair. No reliable data on the effects of microorganisms have been reported yet. Home appliances for women are equipped with a generator, and the person who uses it may subjectively feel that there is a difference in the gloss of the skin and suppression of static in the hair.

It must be mentioned here that the spatial disinfection is not internationally certified in the first place[2]. Additionally, the Ministry of Health, Labor, and Welfare states that it does not fall under the category of drugs or quasi-drugs, whose efficacy and safety have been confirmed for the prevention of COVID-19 [2-4]. Regardless of whether this tool is effective or not, at this point, we have no choice but to assume that it is only used as a miscellaneous article to give a sense of security.

CONCLUSION:

It is difficult to speculate that even medical professionals, including doctors, are well-aware of the differences in the terms, disinfection, and sterilization[6]. Therefore, when choosing a product for preventing COVID-19 for yourself or your family, you may not be equipped with sufficient knowledge. Even the knowledge of medical professionals is thought to be limited to their jobs, and this is just a part of it. Whether it can be applied to the human body or not, and because the corresponding microorganisms differ depending on the antibacterial spectrum, it is necessary to change the drugs used for therapeutic purposes. As summarized in Table 1, such differences in the definitions have been known for a long time, and thus, are not necessarily new findings. However, many of us cannot perform the right distinction. Through these definitions, we revealed that most of these methods exert no significant effect on COVID-19 prophylaxis, and unfortunately, we are not even aware of this fact. It is because of this ignorance that a certain number of people do not take proper preventive measures[2]. The elimination of the virus using ion generation, which was known to be a pseudo-scientific content in the past, has not been scientifically supported yet. However, some people think that those who take proper measures (in this case, use an air purifier equipped with an iron generator) are better than those who do not implement them. We would like to scientifically clarify whether such content is true or false as soon as possible. Conversely, the chlorine-

based air-volatile formulations are known to be effective at high concentrations. However, since this gas is harmful, it becomes difficult to use such a method of volatilizing it in the air unless the concentration is lowered to the extent that it does not harm the people. Alternatively, the distributor or country should provide proper information that should be considered for their use at high concentrations only when there is no one present, or that it may corrode the nearby objects. It is also difficult for the general public to understand, and thus, it can be stated that proper knowledge is currently missing. Therefore, with this study, we would like to help people acquire proper information to prevent COVID-19 infection.

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Table No. 1: Differences in the meaning of different terms

Terms	**Meaning / Application**	**Range and removal ability of microorganisms**	**Examples**	**Comments**
Antimicrobial (antibacterial)	Preventing the growth of bacteria and simulating an environment where it is difficult for the bacteria to survive.	The virus is not targeted in this process. According to the definition of the Ministry of Economy, Trade, and Industry, it involves only bacteria. However, the type and range of bacteria have not been specified.	Kitchen utensils, toys, computer supplies, slippers, toilet seats, sand in the sandbox, etc.	More products need to be included than before. The effect is not always confirmed. It is thought to be related to promoting the onset of allergies.
Disinfection (removing or eliminating bacteria and viruses)	Removing bacteria and viruses and reduce their number to a significant extent (even if you do not kill the bacteria, it is good to	There is no clear rule on the type and degree of reduction of microorganisms. As defined by the Japan Soap and Detergent Association, it does not include fungi, such as	Sprays, gels, wet sheets, detergents, air purifiers, etc.	Especially in Japan, many products have been introduced in the market recently. This term is used because it is not a drug or quasi-drugs and cannot be labeled even if it exhibits bactericidal or disinfecting effects.

	reduce it). Microbiologically, to improve the cleanliness.	mold and yeast.		Based on an extreme theory, disinfection is done even if you wash your hands with water.
Pasteurization (disinfection)	Killing the bacteria and viruses to a certain extent.	There is no clear indication for the type and degree of reduction of microorganisms.	Disinfectants, medicated soaps, etc.	Under Japanese law, only pharmaceuticals and quasi-drugs can be labeled as sterilized (miscellaneous goods, such as detergents and bleach, are not considered here). Sterilization up to only 1% is also acceptable by definition (but it cannot be said that the effectiveness is guaranteed).
Antisepsis (disinfection)	Detoxify pathogenic microorganisms.	It involves many microorganisms, but the rate of death or elimination has not been determined. Inactivates or keeps the microorganisms away, so that they do not become pathogenic.	In addition to disinfecting with drugs, like disinfectants, there are also other methods, such as boiling, exposure to sunlight, ultraviolet rays, and	Limited to pharmaceuticals and quasi-drugs. The purpose is to detoxify, not necessarily kill, but inactivate the infectious organisms or keep them away to an extent that they do not become pathogenic.

			incineration.	
Sterilization (disinfection)	Completely reduce the number of microorganisms to zero (death or elimination).	Eliminate all microorganisms, such as bacteria and viruses. In the Japanese Pharmacopoeia, the number should be less than one-millionth.	Sterilized gauze, surgical tools, syringes, etc.	This method involves the use of electromagnetic waves or radiation, or high voltage or high heat. The effect is well-defined and is most powerful in eliminating the bacteria. This term is used for equipment, etc., as it cannot be used for humans. Table 2 shows further details of the contents.

Based on the contents of references 5-9.

Table No. 2: Classification of the sterilization methods

Major classification	Subcategory	Method	Applicable substances	Procedures and conditions	Possible at home
Heating	Flame	Heating in flame.	Used for items made of glass, porcelain, metal, etc. that is not damaged by flames.	Usually, it requires heating for several seconds or more in the flame of a Bunsen burner or an alcohol lamp.	○
	Dry heat	Heating in dry air.	Used for glass, porcelain, metal or textile	There are methods, such as heating	×

			articles, mineral oils, fatty oils, reagents, or solid pharmaceuticals that can withstand a high degree of dry air.	directly using gas, electricity, or circulating heated air to maintain a dry and high-temperature condition. In the case of direct heating, the procedure is performed under the following conditions: 3-5 hours at 135-145°C 2-4 hours at 160-170°C 0.5-1 hour at 180-200°C	
	High-pressure steam	Heating in saturated steam at a suitable temperature and pressure.	Used for glass, porcelain, metal, rubber, paper or textile articles, water, media, reagents/test solutions, liquid pharmaceuticals, etc. that can withstand high-temperature and high-pressure	This procedure is performed under the following conditions: 30 minutes at 115°C 20 minutes at 121°C 15 minutes at 126°C	×

			steam.		
	Free-flowing steam	Direct distribution of heated steam.	Used for glass, porcelain, metal, rubber or fiber articles, water, media, reagents/test solutions, or liquid pharmaceuticals that may undergo alterations upon using the dry heat or high-pressure steam methods.	Perform for 30-60 minutes in circulating steam at 100°C.	×
	Boil	Submerge in boiling water and heat.	Used for glass, porcelain, metal, rubber or fiber articles, media, reagents/ test solutions, liquid pharmaceuticals, etc. that may undergo alterations upon using the dry heat or high-pressure steam methods.	Boil for at least 15 minutes.	○
	Intermittent	Repeat heating 3-5	Used for rubber articles, media,	Perform under the conditions	×

		times once a day for 30-60 minutes in water at 80-100°C or in circulating steam.	reagents/ test solutions, liquid pharmaceuticals, etc. that may be deteriorated upon using the dry heat or high-pressure steam method.	described on the left. During heating or heat suspension, the temperature is kept at 20°C or higher, which is suitable for the growth of microorganisms.	
Filtration		Filter using a suitable filtration device.	It is used for gases, water, and media containing soluble and heat-unstable substances, test solutions, or liquid pharmaceuticals.	A membrane filter, a porcelain filter, or similar ones are used as the filtration device.	×
Irradiation	Radiation	Irradiate with gamma rays generated from a radiation source containing radioactive isotopes.	Used for glass, porcelain, metal, rubber, plastic, or fiber articles that can withstand radiation.	A radiation source containing ^{60}Co or ^{137}Cs is used.	×
	Ultraviolet	Irradiate with ultraviolet rays.	Used for relatively smooth article	Ultraviolet rays with a wavelength near	△

			surfaces, facilities, equipment, water, pharmaceuticals, etc. made of glass, metal, rubber, plastic, or fiber that can withstand ultraviolet irradiation.	254 nm are used.	
	High frequency	Directly irradiate with high frequencies and use the generated heat.	Used for water, medium, test solution, or liquid medicine that can withstand high-frequency irradiation.	High frequencies of 915 or 2450 MHz are used.	×
	Gas	Using a gas, such as ethylene oxide or formaldehyde.	Used for glass, porcelain, metal, rubber, plastic or textile articles, facilities, equipment, or powdered pharmaceuticals that are not deteriorated by the gas used.	A gas sterilizer is mainly used to control temperature, humidity, gas concentration, and time.	×
	Chemical	Using a	Used for glass,	Alcohol, 0.02-	○

		chemical solution.	porcelain, metal, rubber, plastic or textile articles, fingers, sterile boxes, or sterile equipment that are not deteriorated by the chemicals used.	0.1% benzalkonium chloride solution, cresol water, formalin water, etc. are used.	

Sterilization is defined here as the killing of microorganisms.

○ indicates a sterilization method that is easy to implement, △ is a method that is a little difficult to implement, and × is a method that cannot be used in general households.

The contents of reference 10 have been reorganized in this table.

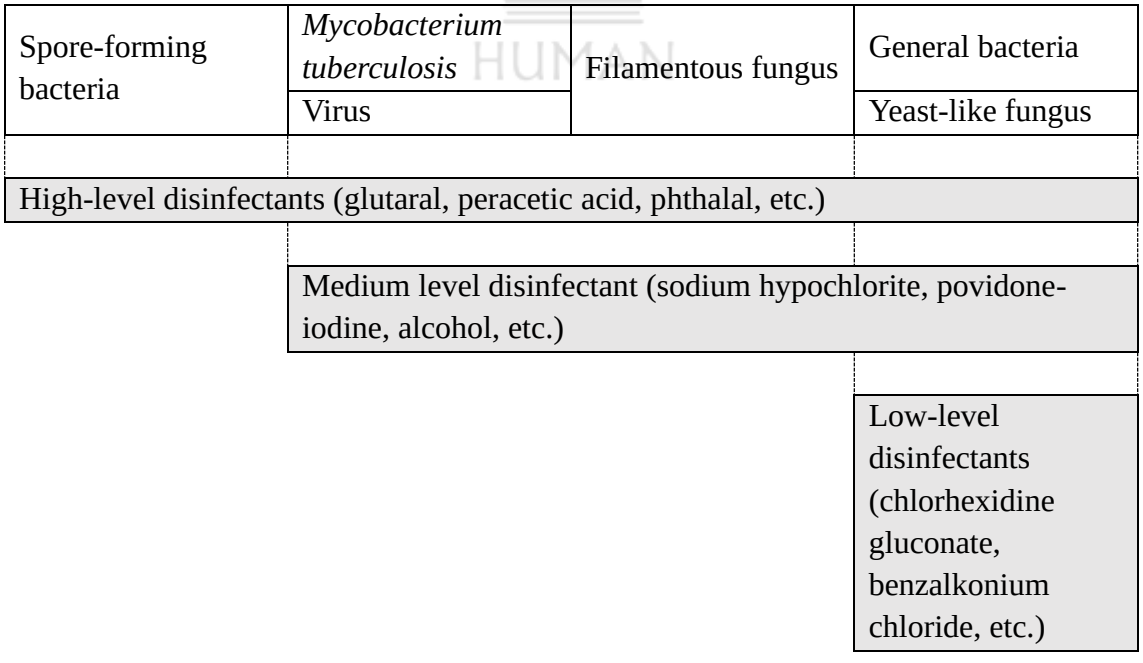

Figure no. 1. Antibacterial spectrum of the typical disinfectants

The antibacterial spectrum represents a range of susceptible microorganisms exhibiting a growth inhibitory effect.

This content is also used for a selection of therapeutic agents.

This is a modified version of a figure in reference 6).