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HAND SANITIZERS BID FAREWELL TO GERMS ON SURFACE AREA OF HANDS

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ABSTRACT

Hand sanitizers work by dissolving the cell membrane of the bacterium and then denaturing the proteins that are essential to bacterial life. Sanitizers are type of antimicrobial that kills or irreversibly inactivates at least 99.9% of all bacteria, fungi and viruses (called microbials, microbiologicals, microorganisms) present on a surface. Most sanitizers are based on toxic chemicals such as chlorine, iodine, phenol, or quaternary ammonium compounds and which (unlike some antiseptics) may never be taken internally.

KEYWORDS: WHO, FDA, CDC, Hygiene, Humectants, Ethanol, Glycerol, Aminomethyl propanol, Caprylyl alcohol, Benzalkonium chloride, Isopropyl myristate, Tonicity, Protein denaturation

INTRODUCTION

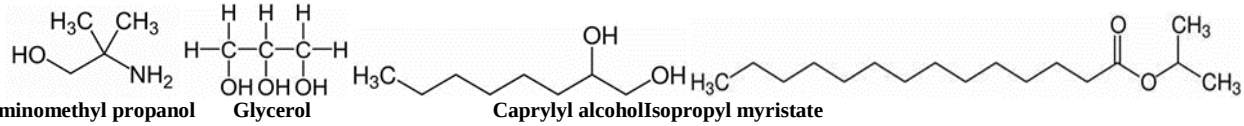
According to: WHO (World Health Organization): *Hand sanitizer works great and is very effective at killing bacteria, fungi and viruses*.

According to: FDA (Food and Drug Administration): *Consumers can continue to use hand sanitizer products with confidence as this regulatory process moves forwardto work to ensure that these products remain available to help people stay clean and healthy in homes, day care centers, restaurants, and offices across the Nation*.

According to: CDC (Centres for Disease Control): *Practicing hand hygiene is a simple yet effective way to prevent infections* to *continue to use healthcare antiseptic products currently recommended*.

Hand sanitizers have become the norm when speaking about hygiene. Billions of people around the globe regularly use them to keep their hands clean and safe. Mothers pass a sanitizer bottle to their kids after their play session and you probably (and hopefully) never leave a public washroom before using the available hand sanitizer.From actually cleaning hands to simply enjoying the cooling sensation, hand sanitizers are used multiple times every day.

Since most hand sanitizers contain ethanol as the active ingredient, they are sometimes gulped by people looking for a cheap substitute for regular drinking alcohol. Manufacturers, therefore, add bitter-tasting compounds, such as aminomethyl propanol, to avoid such scenarios.



Aminomethyl propanol **Glycerol** **Caprylyl alcoholIsopropyl myristate**

Figure 1: Humectants.

Humectants are the active ingredients of hand sanitizers, i.e., alcohol, causes dry skin. Thus, ingredients such as glycerin, caprylyl glycol, and isopropyl myristate are used as conditioners to help prevent the skin from drying. Fragrances and polymers are added to provide a pleasant odour and a gel-like consistency, respectively.[1]

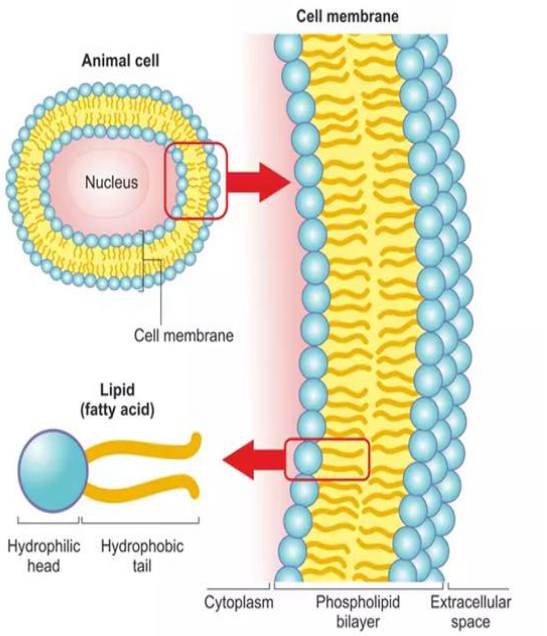


Figure 2: Biochemistry of lipid layer.

How do hand sanitizers kill bacteria?

Bacterial cells, like any other cells, have a plasma/cell membrane that encloses all the other organelles. The membrane acts as a barrier between the interior of the bacterium and the outside environment. Any damage to the cell membrane would open the floodgates for bacterial death. This is exactly how hand sanitizers work. They dissolve/sever the cell membrane first and then go on to denature the proteins inside the bacterial cells by the disintegration of the cell membrane. The cell membrane of a bacterium is primarily composed of phospholipids. Phospholipids are a class of lipids containing two hydrophobic (water-hating & non-polar) fatty acids on one end, referred to as 'tails', and a 'head' that is hydrophilic (water-loving & polar) in nature. The phosphate group attached at the head makes it polar and hydrophilic. The two parts are ordinarily joined together by a glycerol molecule.The phospholipid bilayer of an animal cell is a thin membrane made of two layers of lipid molecules. The interior of a cell and the exterior is mostly surrounded by water (polar compound), so the hydrophobic non-polar tails cower inside while the hydrophilic polar headlines the interior and exterior of the cell membrane.The tails might be hydrophobic, but they are also lipophilic (lipid-loving) in nature. Hand sanitizers exploit this lipophilic nature of the tails to disintegrate the cell membrane due to the "like dissolves like" principle. The non-polar tails dissolve readily in other non-polar compounds.[2]

The organic solvents, i.e., propanol or ethanol, used in hand sanitizers are amphiphilic compounds, meaning that they contain both a hydrophilic part and a lipophilic (or hydrophobic) part. They are master solvents and can dissolve both polar and non-polar compounds. Alcohols and water both have oxygen atoms which have two lone pair of electrons. Alcohol in sanitizer reacts with water molecule of bacterial cell cytoplasm and due to common ion effect the water molecules come out from the bacterial cell to make alcohol layer isotonic and cell osmotic pressure rises as the bacterial cell becomes hypertonic because the cellular concentration becomes thick and cell death occurs. Carboxylic acid anion [-COO^-] of protein amino acids make hydrogen bond with hydroxy [OH-] group of ethanol and isoelectric pH of amino acids cross the denaturation point and the whole protein of microorganism gets denaturized.

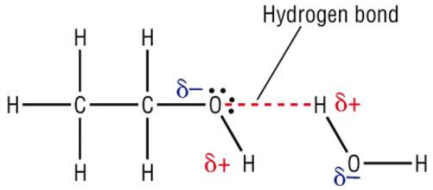


Figure-3: Microorganism cell rupture by tonicity.

Lipids are non-polar compounds and hence are soluble in other non-polar compounds. Ethanol is polar due to the presence of the -OH group and also non-polar because of the hydrocarbon chain [CH_3-CH_2-OH].Thus, as soon as the ethanol molecules in your hand sanitizer come in contact with the cell membrane, they bond with it and

start dissolving the lipophilic tail. The membrane, therefore, loses its structural integrity and gets ruptured in a bunch of different places, spilling out the cell guts. In itself, this would cause bacterial death, as the cell organelles would ooze out, but hand sanitizers take it a step further by even denaturing the cell proteins.

Denaturation of bacterial proteins

You have probably read time and again that proteins are the key to life. Destroy the protein molecules and the life of the organism will follow. Denaturation is the breaking down of protein molecules by the application of external stress. External stress can be in the form of radiation, heat or chemical compounds, such as a strong acid or base, a concentrated inorganic salt or an organic solvent. Isopropyl alcohol, ethanol and propanol are all examples of organic solvents.

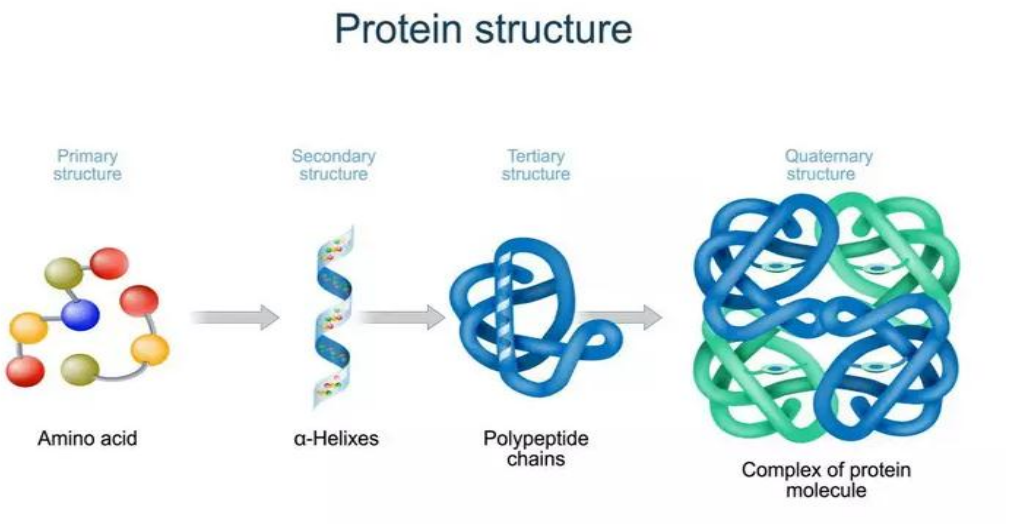


Figure 4: Primary, Secondary, Tertiary and Quaternary structure of protein.

Proteins are polymers of amino acids and have four different levels of structural organization.The structure of a protein plays a definitive role in deciding whether the molecule can properly perform its functions or not. Disturbing the protein structure in any way or manner would render them worthless and ultimately lead to cell death.

Hand sanitizers denature proteins by meddling with the hydrogen bonds in the secondary and tertiary protein structures. In the secondary structure, hydrogen bonding appears among amide groups, while in a tertiary structure, hydrogen bonds are formed by the side chains.Ethanol breaks down hydrogen bonds between the side chains of the tertiary structure and thus, unfolds the protein molecule.

After weakening the cell membrane, alcohol molecules begin rushing in and breaking these hydrogen bonds. Once the new bonds between the protein molecules and alcohol are formed, the protein molecules lose their structure and, consequently, their functionality. As already established, without these proteins functioning, the bacterial cell ceases to survive and quickly dies.

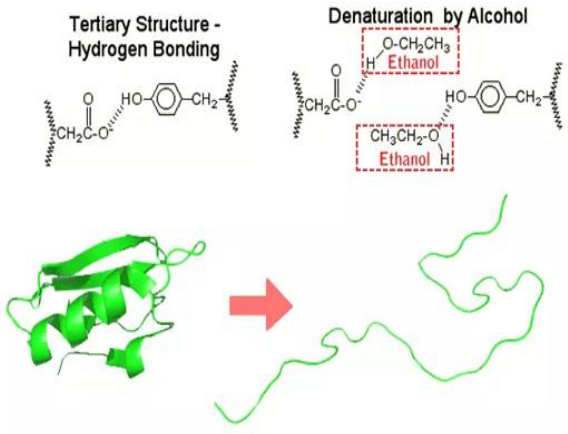


Figure 5: Protein denaturation by alcohol.

Composition of hand sanitizers

If you were to flip the bottle of your hand sanitizer and read the ingredients tab, you would find names such as isopropyl alcohol, ethanol/ethyl alcohol or propanol. Non-alcohol-based hand sanitizers contain antibacterial compounds, such as benzalkonium chloride or triclosan. These are the active components of hand sanitizers and are responsible for getting rid of those nasty bacteria.Isopropyl alcohol is the same stuff used in rubbing alcohol, while ethanol is the key ingredient of the booze that you drink every Saturday night and propanol is nothing but a *structural cousin* to isopropyl alcohol. A hand sanitizer needs to contain somewhere between 60% to 95% of these alcohol compounds to kill any germs. A hand sanitizer with an alcohol concentration below 60% isn't effective at killing germs.One also finds these bottles on restaurant tables, attached to hospital walls and dangling from people's backpacks in cutesy little bottles. The question is, how does this sparkly gel actually kill bacteria?

Hand sanitizer, also called hand antiseptic, handrub, or hand rub, agent applied to the hands for the purpose of removing common pathogens (disease-causing organisms). Hand sanitizers typically come in foam, gel, or liquid form. Their use is recommended when soap and water are not available for hand washing or when repeated hand washing compromises the natural skin barrier (e.g., causing scaling or fissures to develop in the skin). Although the effectiveness of hand sanitizer is variable, it is employed as a simple means of infection control in a wide variety of settings, from day-care centres and schools to hospitals and health care clinics and from supermarkets to cruise ships.

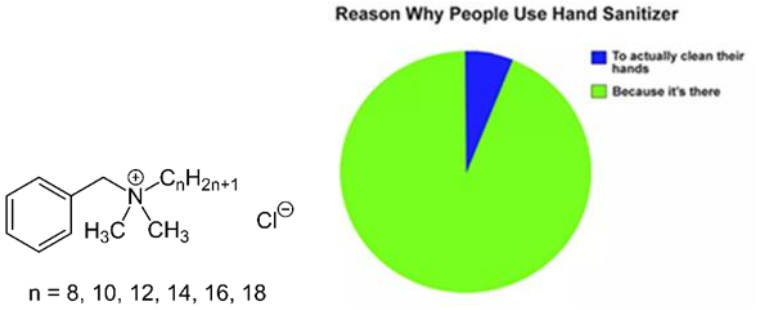


Figure 6: Benzalkonium chloride.

Types of Hand Sanitizers

1. Alcohol based (Isopropyl/Ethanol)
2. Ammonia based (Benzethonium/Benzalkonium Chloride)
3. Silver/Iodine based
4. Chlorine based (Chlorhexidine/Cetrimonium)
5. Triclosan based
6. Essential Oil based (Cinnamon, Clove, Thymol)

Depending on the active ingredient used, hand sanitizers can be classified as one of two types: alcohol-based or alcohol-free. Alcohol-based products typically contain between 60 and 95% alcohol, usually in the form of ethanol, isopropanol, or n-propanol. At those concentrations, alcohol immediately denatures proteins, effectively neutralizing certain types of microorganisms. Alcohol-free products are generally based on disinfectants, such as benzalkonium chloride (BAC), or on antimicrobial agents, such as triclosan. The activity of disinfectants and antimicrobial agents is both immediate and persistent. Many hand sanitizers also contain emollients (e.g., glycerin) that soothe the skin, thickening agents and fragrance.

Benzalkonium chloride, also known as BZK, BKC, BAK, BAC, alkyldimethylbenzylammonium chloride and ADBAC, is a type of cationic surfactant. It is an organic salt classified as a quaternary ammonium compound. It has three main categories of use: as a biocide, a cationic surfactant and as a phase transfer agent. ADBACs are a mixture of alkylbenzyldimethylammonium chlorides, in which the alkyl group has various even-numbered alkyl chain lengths.Benzalkonium chloride also possesses surfactant properties, dissolving the lipid phase of the tear film and increasing drug penetration, making it a useful excipient, but at the risk of causing damage to the surface of the eye.

Biological activity: The greatest biocidal activity is associated with the C12 [dodecyl]& C14 [myristyl] alkyl derivatives. The mechanism of bactericidal/microbicidal action is thought to be due to disruption of intermolecular interactions. This can cause dissociation of cellular membrane lipid bilayers, which compromises cellular permeability controls and induces leakage of cellular contents. Other biomolecular complexes within the bacterial cell can also undergo dissociation. Enzymes, which finely control a wide range of respiratory and metabolic cellular activities, are particularly susceptible to deactivation. Critical intermolecular interactions and tertiary structures in such highly specific biochemical systems can be readily disrupted by cationic surfactants.Benzalkonium chloride solutions are fast-acting biocidal agents with a moderately long duration of action. They are active

against bacteria and some viruses, fungi and protozoa. Bacterial spores are considered to be resistant. Solutions are bacteriostatic or bactericidal according to their concentration. Gram-positive bacteria are generally more susceptible than gram-negative bacteria. Its activity depends on the surfactant concentration and also on the bacterial concentration (inoculum) at the moment of the treatment. Activity is not greatly affected by pH, but increases substantially at higher temperatures and prolonged exposure times.[3]

Effectiveness

The effectiveness of hand sanitizer depends on multiple factors, including the manner in which the product is applied.

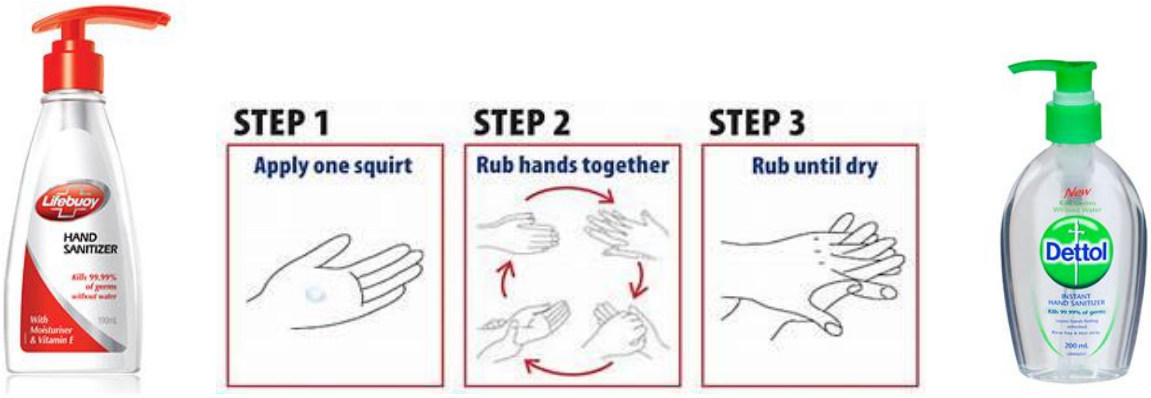


Figure 7: Hand sanitizers.

(e.g., quantity used, duration of exposure, frequency of use) and whether the specific infectious agents present on the person's hands are susceptible to the active ingredient in the product.In general, alcohol-based hand sanitizers, if rubbed thoroughly over finger and hand surfaces for a period of 30 seconds, followed by complete air-drying, can effectively reduce populations of bacteria, fungi, and some enveloped viruses (e.g., influenza A viruses). Similar effects have been reported for certain alcohol-free formulations, such as SAB (surfactant, allantoin and BAC) hand sanitizer. Most hand sanitizers, however, are relatively ineffective against bacterial spores, nonenveloped viruses (e.g., norovirus), and encysted parasites (e.g., Giardia). They also do not fully cleanse or sanitize the skin when hands are noticeably soiled prior to application.Despite the variability in effectiveness, hand sanitizers can help control the transmission of infectious diseases, especially in settings where compliance with hand washing is poor. For example, among children in elementary schools, the incorporation of either an alcohol-based or an alcohol-free hand sanitizer into classroom hand-hygiene programs has been associated with reductions in absenteeism related to infectious illness. Likewise, in the workplace, the use of alcohol-based hand sanitizer has been associated with reductions in illness episodes and sick days.In hospitals and health care clinics, increased access to alcohol-based hand sanitizer has been linked to overall improvements in hand hygiene.

Indian Hand Sanitizers

Figure 8: Zapcare Hand Sanitizer

Klenza Hand Sanitizer

Zapcare Sanitize Hand Wash
This Sanitizer is an alcohol free, fragrance-free, water-based and Non-flammable hand sanitizer.This is the only hand sanitizer available in India which is effective for more than 6 hours after the application. It has 0.2% Benzalkonium Chloride which is a Broad-spectrum antimicrobial that kills Swine Flu – H1N1 (Subtype of Influenza A Virus), MRSA (Methicillin-resistant *Staphylococcus aureus*), Metallo-Beta-Lactamase-1 (NDM-1), *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella pneumonia* & Gram negative bacteria in 30 seconds and protects the hand for 6 hours.

CoIngredients: Benzalkonium Chloride, Cetrimonium Chloride, Vitamin E, Aloe Vera Extract, Glycerin, Propyl Paraben Sodium, Demineralized Water
How it smells: It smells like deodorant
How it feels: White surf like foam
Substantivity: 6.5 hours
Zone of Inhibition: 10/10
Price: Rs.55 for 60ml

Klenza Alcohol Free hand sanitizer
The Klenza Hand Sanitizer, is a unique patent pending pure silver-based technology which uses Ionized Silver as the main ingredient. Klenza is a green product that doesn't use any harmful ingredients like alcohol, triclosan or paraben. Klenza is safe on all skin types and is exceptionally gentle even on the hands of kids (3+ years). As it has SLS and costlier than zapcare.

Klenza is tested as per ASTM E 2755 which proves that it offers 3 hours of protection from germs and as per ASTM E 2315-03,it kills 99.999% of germs instantly without alcohol.

Ingredients: Aqua, Silver, Betaine, Disodium EDTA, Glycerin, Sodium Lauryl Sulfate, Fragrance
How it smells: It smells like body soap
How it feels: White surf like foam
Substantivity: 3.25 hours
Zone of Inhibition: 10/10
Price: Rs.90 for 50ml

Figure 9: Winova Alcohol Free SanitizerKeisha Hand Sanitizer.

Winova Baby Smooth – Alcohol Free Sanitizer
This is another alcohol free Benzalkonium Chloride sanitizer which is even safe for babies. Also European Standard Test Certified (EN1500, EN14476, EN13697).

It has 0.1% Benzalkonium Chloride which is Broad-spectrum antimicrobial that kills bacteria, fungi and viruses in 30 seconds and protects the hand for 3 hours. Its free from preservatives and additives.

Ingredients: Benzalkonium Chloride, Purified Water
How it smells: It smells like soap
How it feels: White surf like Foam
Substantivity: 2.61 hours
Zone of Inhibition: 9/10
Price: Rs.85 for 50ml

Keisha Hand Sanitizer
Keisha is the most powerful sanitizer which is an 70% Alcohol based sanitizer with added Chlorhexidine di gluconate which kill all harmful germs than any other sanitizer. Chlorhexidine is active against Gram-positive and Gram-negative organisms, facultative anaerobes, aerobes and yeasts. An Alcohol percentage of 60-80% destroys the cell wall/membrane of bacteria by denaturing their proteins and dissolving their lipids (effective against most bacteria, fungi and some viruses; ineffective against bacterial spores). If you use 100% Alcohol instead, the bacteria get 'sealed' and they will survive.

How it smells: It smells like spirit
How it feels: Watery
Substantivity: 8 minutes
Zone of Inhibition: 10/10
Price: Rs.50 for 50ml

Figure 10: Himalaya Hand SanitizerLifebuoy Total Hand Sanitizer.

Himalaya PureHands Hand Sanitizer
Himalaya's PureHands is an effective, herbal, 60% alcohol-based hand sanitizer, which kills 99.9% of germs, prevents infection, and ensures total hand hygiene.

Pure Hands contains extracts of herbs like Coriander, which have potent antimicrobial properties and Lime, which is a natural bactericidal. In addition, the active ingredients of Neem, which are antibacterial, fungicidal and antiviral, safely keep viruses, bacteria and fungi at bay. It protects the skin from oxidative damage and also prevents itching. Even though its a mixture of herbal ingredients it has strong spirit smell and cannot be recommended it to women.[4]

Ingredients: Hrivera (*Coleus vettiveroides*), Coriander (*Coriandrum sativum*), Lime (*Citrus aurantium*), Ushira (*Vetiveria zizanioides*), Neem extracts (*Azadirachta indica*), Alcohol 60%.
How it smells: It smells like gin
How it feels: Watery gel
Substantivity: 35 minutes
Zone of Inhibition: 9/10
Price: Rs.55 for 50ml

Lifebuoy Total Hand Sanitizer
This is a 62.25% mixed-alcohol based sanitizer formulated with an instant anti-bacterial formula that eliminates all bacteria in 10 seconds, leaving your hands healthy and germ free. Just rub onto your hands and this non sticky hand sanitizer can eliminate up to 99.99% germs in 10 seconds. Possibly this is one of the fastest acting sanitizers. It has been clinically proven that it kills the H1N1 virus without water in 10 seconds.

Ingredients: Ethyl Alcohol 95% v/v IP 55% w/w, Isopropyl Alcohol IP 10% w/w, Vitamin E
How it smells: It smells like spirit
How it feels: Gel
Substantivity: 1 minute
Zone of Inhibition: 9/10
Price: Rs.60 for 55ml

Figure-11: Dr. Batra's Hand SanitizerGodrej Protekt Hand Sanitizer.

Dr. Batra's Hand Sanitizer
Dr. Batra's non-alcoholic spray hand sanitizer contains Tulsi extract which possesses anti – bacteria properties & anti-fungal features thus helps in eradicating micro-organisms present on the skin also contains glycerin which's a skin protector & also it has added Benzalkonium Chloride and Chlorhexidine di gluconate for extra protection. Even though it has all the powerful ingredients it fails to perform well in our test due to the poor concentrations of active ingredients.

Ingredients: Indian Basil-tulsi (*Ocimum sanctum*), Castor Oil, Benzalkonium Chloride, Chlorhexidine gluconate, Citric Acid.
Price: Rs.105 for 100ml

Godrej Protekt Hand Sanitizer
Godrej Protekt Not Just Another Hand Sanitizer is a 0.125% Benzalkonium Chloride based sanitizer and the company claims that it protect the hands for 8 hours. But in our tests, it works only for 2 hours. We didnt also like the watery white spray and the smell of this product (you will get the same solution if you mix Dettol disinfectant in water).
Ingredients: Benzalkonium Chloride
How it smells: It smells like floor cleaner
How it feels: Soap Water
Substantivity: < 1 minute
Zone of Inhibition: 9/10
Price: Rs.50 for 30ml

Figure 12: Dettol Instant Hand SanitizerZUCI Junior Instant Hand Sanitizer.

Dettol Instant Hand Sanitizer
It has mild fragrance but too thick in its consistency.
Ingredients: Denatured Alcohol- 72.34% w/w, PEG/PPG-17/6 copolymer, Propylene glycol, Acrylate /C10-30 alkyl acrylate, cross-polymer, Tetrahydroxpropylethylenediamine.
How it smells: It smells like vodka
How it feels: Thick Gel
Substantivity: < 1 minute
Zone of Inhibition: 8/10
Price: Rs.60 for 50ml

ZUCI Junior Instant Hand Sanitizer
Its 60% alcohol-based product and comes in different fruit flavours and one of the best smelling sanitizers, specially the green apple flavour. But too much watery, dries fast and contains granules.
Ingredients: Ethyl Alcohol 95% v/v IP 63.15% w/w, Isopropyl Alcohol IP 3.2%, Vitamin E
How it smells: It smells like wine
How it feels: Watery Gel
Substantivity: < 1 minute
Zone of Inhibition: 7/10
Price: Rs.50 for 30ml

So which Hand sanitizer should you use? 1. For New-born: till three years, do not apply any sanitizer or handwash, let the baby develops some immunity. 2. For Kids < 10 years old:Winova Baby Smooth Alcohol-Free Sanitizer. 3. For Students > 10 years old: Zapcare Sanitizer (apply after breakfast and lunch). 4. For Housewives: Lifebuoy Sanitizer 5. For Engineers: Keisha Hand Sanitizer/Cleanser 6. For Doctors & Nurses: Klenza Alcohol Free hand Sanitizer. 7. All others: Use Himalaya Pure Hands

Why Sanitizers only kill 99.99% germs and not 100%?
You may wonder to watch all TV advertisements of soap/sanitizers claiming to kill only 99.99% and not 100%. This is because of the ability to Resist by the microorganisms. The resistance is present when actually the organisms are avoiding contact with the sanitizing chemical because a biofilm is present. Bacteria such as *Escherichia coli*, *Salmonella spp*., *Listeria spp*., *Campylobacter spp*. and several others can produce biofilms. This is why no one claims to kill 100% germs.

So When should you use a hand sanitizer? 1. Before and after attending to a sick person. 2. Before touching a new born baby or infant. 3. After visiting a hospital or nursing home. 4. During travel or after using public transports including airports. 5. After using computer keyboard and mouse. 6. After using the washroom or public toilet. 7. After driving a car or bike. 8. After

fitness & indoor sports. 9. After handling currency notes or ATM. 10. After shopping in any mall or departmental stores. 11. After doing household work like cleaning, dusting, handling garbage, etc.

When should you use a hand wash?1. Before Preparing food. 2. Before touching or eating food. 3. Before handling cheap plastic bottles. 4. After sneezing. 5. After using a toilet. 6. After playing with animals.

Always use a Non Triclosan based Hand wash or better use normal soap/liquid soap. You can apply Hand sanitizers after washing the hand.Hand Sanitizers are part of our modern lifestyle and used everywhere from washbasins to holiday trips. Even though we Indians love to use Hand wash liquids, the use of sanitizing liquid is more hygiene and unavoidable. The advantage of Hand Sanitizer over Handwash is that they are powerful, faster acting and broad spectrum against microorganisms and can be used water-less. So, this is how hand sanitizers work, by first softening the defence wall (cell membrane) of the bacterial cell and then attacking their valuable jewels (proteins). However, hand sanitizers don't always work. Researchers have found hand sanitizers to be ineffective when the hands are visibly dirty and also less effective overall than washing hands with regular soap and water. Thus, the FDA advises washing your hands using regular soap and water and only using hand sanitizers when those resources are not available.[5]

CONCLUSION

Hand is a such organ of body which touches anything with its fingers and palm so it must be sanitized before doing anything. Hand sanitizers were developed for use after washing hands or for those times when soap and water are not available. They are gels that contain alcohol in order to kill the germs present on the skin. The alcohol works immediately and effectively in order to kill bacteria and most viruses. Alcohol can be very drying to the skin, so most brands of sanitizers also contain a moisturizer to minimize skin dryness and irritation.To use hand sanitizers effectively, place a small amount, the size of your thumbnail, on the palm of your hand and rub it over your entire hand, including in your nailbeds. If the gel completely evaporates in less than 15 seconds, you have not used enough product.Hand sanitizers are convenient, portable, easy to use and not time consuming.Several studies have concluded that the risk of spreading gastrointestinal (stomach) and respiratory infection is decreased among families who use hand sanitizers.Commercially prepared hand sanitizers contain ingredients that help prevent skin dryness. Using these products can result in less skin dryness and irritation than hand-washing.Studies show that adding hand sanitizers to classrooms can reduce student absenteeism due to illness by 20%. What's more, many kids think instant hand sanitizers are fun to use.

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