Chemical Disinfectants & Antiseptics Agents Efficacy Testing in Yemen, Between International Standards and Real Practices and Parties Performance Evaluation.

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Abstract:

The research aims to explore the current situation of chemical disinfectants and antiseptic chemical agents in Yemen. The study adopts a descriptive and analytical approach to explore the Yemeni context with regard to the adherence of the international standards for testing disinfectants efficacy. analyze National legislations, an interview of relevant authorities' personnel, and the results of a questionnaire measuring consumers real practices of Disinfectants & Antiseptics agents efficacy testing, The research results indicate an absence of National manufacturing protocol and the absence of following any related international standards due to the suffering of insufficient resources needed for obtaining international standards, which justifies the weak infection control performance and the spread of diseases and low global ranking of Yemen due to untrusted chemical disinfectant agents' specifications and poor product declaration procedures caused by unfollowing relevant international standards of testing disinfectants efficacy. Furthermore, the questionnaire results reveal low consumers trust in related governmental authorities' performance and low trusting of Yemeni disinfectant products. Finally, a sum of recommendations is given to address this issue which is mainly initiating an establishment with the name The National Yemeni Center/ Institute of Health, Safety& Environment responsible for creating protocols, standards, policies, procedures and manuals for regulating chemical products and safety procedures.

Keywords: Yemen Healthcare, Infection Control, YSMO, disinfectant efficacy testing, industrial standards.

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1. Introduction:

1.1. Yemen Healthcare situation:

a. Yemeni Healthcare issues:

Yemen suffers from a catastrophic health condition described by World health Organization as the worst in the 21st century[1], with high rates of infectious diseases spreading across all the parts of Yemen. This is attributed to the poor performance of infection control, medical waste management, and diseases surveillance & reporting which resulted in the spread of many diseases such as cholera that scored more than 2.5 million suspected cases and 3997 deaths [2]. Moreover, a statement of the Yemeni Ministry of Health (i.e. Northern Part of Yemen) statistics of epidemiological diseases during 2022 in various governorates indicating 2106534 cases of upper respiratory diseases, 1159614 cases of watery diarrhea, 760656 cases of lower respiratory diseases, sever acute respiratory diseases were 4550 cases, bloody diarrhea 47550 cases, 14508 patients of cholera, typhoid 196287 patients, measles 18597 cases, 226 cases of polio, viral hepatitis (A+E) were14039 cases, and diphtheria were 1105 cases.[3] All of these diseases can be transmitted due to poor disinfecting practices.

However, disinfection is considered as a very important factor for infection control, and medical waste management in the healthcare services. Therefore, all above statistics might be an indicator of poor disinfection practices in Yemen. They draw our attention to the poor quality of the disinfectant agents and products and poor efficacy testing practices.

[1] Source: https://www.undp.org/yemen/stories/yemens-first-centre-infectious-diseases-inaugurated-hodeidah
[2] WHO report 2016-2021
[3] Source: Yemeni postal agency- www.ypagency.net/498321

b. **Disinfectants in the Yemeni context**:

Chemical disinfectant agents have a big role in the healthcare system, occupational and environmental safety aspects, especially in the case of unfollowing the international standards and practices in using, choosing, manufacturing, permitting, and waste management of these chemicals, which might lead to:

- Occupational injuries and diseases upon workforce.
- Chemical accidents and property losses.
- Spread of infectious diseases as epidemic and resident diseases.
- High rate of post-operational infection.
- Spreading of infections among patients due to poor environmental cleaning.
- Infected goods via manufacturing processes.
- More burden on the insurance, healthcare sector, economic and social systems.
- Low trust of national products especially chemical disinfectant products.
- Huge rate of fatalities on the population and low life expectancy.
- Disastrous environmental impacts and pollution.
- Rapid increasing in cancers and acute diseases cases.
- Low trust of Yemeni medical and healthcare quality.
- Continuous draining funds facing infection control actions without results.
- Unsuitable disinfectants will generate new resistance strains of pathogens.

All these impacts and more will accrues as long as no international standards are followed in chemical disinfectant management especially testing of its efficacy. Below is a figure describing the systemic interaction of disinfectants efficacy testing importance:

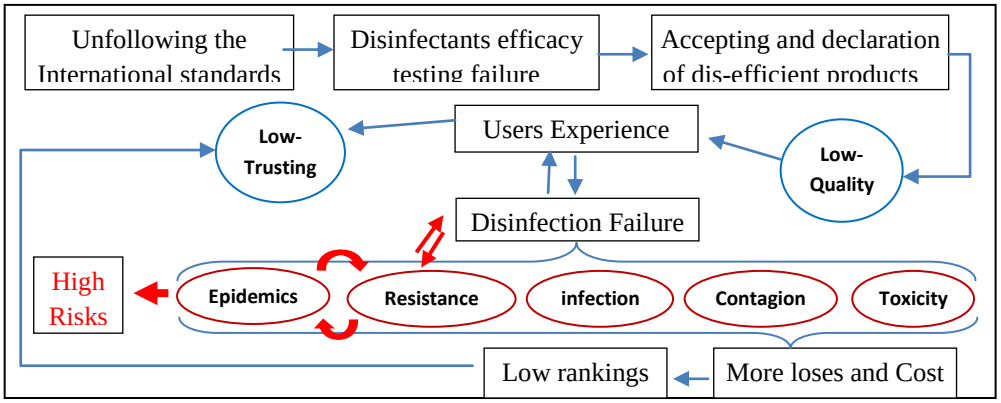

Diagram (1) Shows the Systemic interaction of disinfectants efficacy testing importance

Examples of Infringing Products in Yemen: many imported and national infringed disinfectants and sanitizer products have been detected by YSMO[1] and below are some published announcements and warning of non-matching products (at least 12 products are made in Yemen):

Figure (1) of YSMO's announcement of non-matching products[2]

[1] The Yemeni Standardization, Meteorology and Quality Control Organization.
[2] Source YSMO Official website and Facebook page. www.ysmo.org

1.2. Chemical Disinfectants & antiseptics agents:

Disinfectant is a chemical substance or compound used to inactivate or destroy microorganisms on inert surfaces.[1] They can be explained based on the types of substances they are supposed to clean, their grades, their types, and their potency levels. These are illustrated as follows:

a. **Forms**: Chemical agents physically diverse into 3 types that are used to decontaminate the following substances:
   - **Gas**: such agents are used to decontaminate infectious air.
   - **Solid**: they are used to clean solid surfaces. They are manufactured in the form of dye or paint that act as an antibacterial or antiviral
   - **Liquid**: This type of agents is used for decontaminate surfaces and dissolves in infectious liquids, in whatever method. They are often included in mists, paths, soaps and creams, and this form is regarded as the most widely used and the main focus of this research.

b. **Grades**:
   - Instrument grade
   - Hospital grade
   - House/commercial grade

c. **Kinds**: They are named according to each disinfectant biological efficacy such as:
   - **Bactericidal**: They are compounds or substances that destroy bacteria.
   - **Tuberculocidal**: It is a substance or a process which disables or destroys the germs which causes tuberculosis.
   - **Fungicidal**: They are compounds or solutions that destroy fungi.

[1] CDC definition.

- **Virucidal**: It refers to any physical or chemical agent that deactivates or destroys viruses.
- **Sporicidal**: It is a substance or product that kills spores or bacteria.
- **Yeasticidal**: disinfectants prevent yeast and fungal infections from spreading in high-risk areas.
- **Germicide**: It is an agent that destroys microorganisms, especially pathogenic organisms.

d. **EPA Registration Number or EPA Reg**: A hyphenated, two- or three-part number assigned by EPA to identify each germicidal product registered within the United States. The first number is the company identification number, the second is the specific product number, and the third (when present) is the company identification number for a supplemental registrant.

e. Another way to classify them is based on their functions as follows:
   - **Antiseptics:** They are antimicrobial substances or compounds that are applied to living tissues to reduce the possibility of infections.
   - **Disinfectants:** They are only used to decontaminate nonliving surfaces such as tools & floors, and cannot be used as an antiseptic due to its toxicity and health effects.
   - **Sterilant:** They are chemical agents which are used to sterilize important medical devices or medical instruments by killing all micro-organisms.

f. **Levels**:

Disinfections potency levels can be classified into three types based on the degree of microbial killing achieved by the disinfectant and the types of microorganisms that are targeted. These levels can be low, intermediate, and high. Here's a brief overview of each level:

- **Low-level disinfections**: Disinfections of low level are used for surfaces that are not heavily contaminated and do not come into contact with blood or other bodily fluids. It is effective against most bacteria, some viruses, and some fungi, but may not be effective against all types of microorganisms. Examples of low-level disinfectants include quaternary ammonium compounds, phenols, and alcohol-based solutions.
- **Intermediate-level disinfections**: Disinfections of this level are used for surfaces that are moderately contaminated and may come into contact with blood or other bodily fluids. It is effective against most bacteria, viruses, and fungi, but may not be effective against all types of microbial spores. Examples of intermediate-level disinfectants include chlorine-based solutions, iodophors, and hydrogen peroxide.
- **High-level disinfections**: These disinfections are used for surfaces that are heavily contaminated and come into contact with blood or other bodily fluids. It is effective against all types of microorganisms, including bacterial spores, but may not necessarily kill all microbial spores. Examples of high-level disinfectants include glutaraldehyde, peracetic acid, and hydrogen peroxide.

In terms of the numerical classification (1-2-3), this system is specific to the disinfection of medical devices and equipment. The levels correspond to the degree of microbial killing required for different types of medical devices, with level 1 being the lowest level of disinfection and level 3 being the highest. The classification system is as follows:

- **Level (1):** Low level means a disinfectant that rapidly kills most vegetative bacteria as well as medium size lipid containing viruses.
- **Level (2):** Intermediate level means a disinfectant that kills all microbial pathogens except bacterial endospores.

- **Level (3):** High level means a disinfectant is able to kill all microbial pathogens except large numbers of bacterial endospores.

g. **Classification**: according to its origin and chemical branch the following diagram describes Chemical agents' classification:

Disinfectants+Antiseptics- Antiseptics -Disinfectants الأنواع بحسب لون النص لكل مادة كالتالي:-	التصنيف الكيميائي	
Hydrargyri –Dichloridum -Mercuric Amidochloride -Silver nitrate-Copper sulfate-Zinc sulfate -Zinc oxide- Mercuric Chloride -hydrosulfate- Quaternaries-	Metallic salts	Inorganic غير عضوية
Boric acid-Salicylic acid-Solution of ammonia(Lysol-Vindicator)- Acetic & Acide – Paracetic acide- Glutaral- Sodium carbonate- Sodium hydroxide- Hydrochloric acid	Acids and alkalis	
Hydrogen peroxide -Potassium permanganate	Oxidizing	
Iodine alcochol solution- Iodinolum -Ioddicerinum- Povidon- -Iodophorm -Chloramine - Hexachlorophane Chloroxylenol-hypochlorite sudiom-NADCC- tosylchloramide- Chlorine dioxide - Chlorhexidine gluconate- Chlorhexidine- Cetrimide	Halogens	
Pix liquida Betulae (Birch tar)-Ichthyolum-Liniment	PETROLUM	Organic عضوية
Nitrofurasone (Furacilinum)	Nitrofuran	
Aethonium -Decamethoxin- Roccal-Dimexid	Detergents	
Formaldehyde (Formalinum)-Glutaraldehide -Hexamethylentetraminum (Methenamine)	Aldehydes	
Ethyl alcohol- Isopropanol	Alcohols	
Phenol -Cresol Resorcinol –Thymol- Benzylbenzoat	Phenol	
Methylenum blue- Brilliant green (Viride nitens)-Etacridin lactate- acriflavine	Dyes	

Figure (2) Disinfectants Classifications and Types[1]

h. **Efficacy**: Each Chemical agent has a different effectiveness against various organisms in accordance of each organism biological structures and each agent mechanism. In addition, some types of organisms have resistance to chemical agents of low level due to the organisms' natural abilities or the immunity they gain or the heritable change in the nucleotide sequence of the organism's DNA.

The following picture describes the different chemical agents' groups and their efficacy:

[1] This image was taking form a previous awareness published by the researcher.

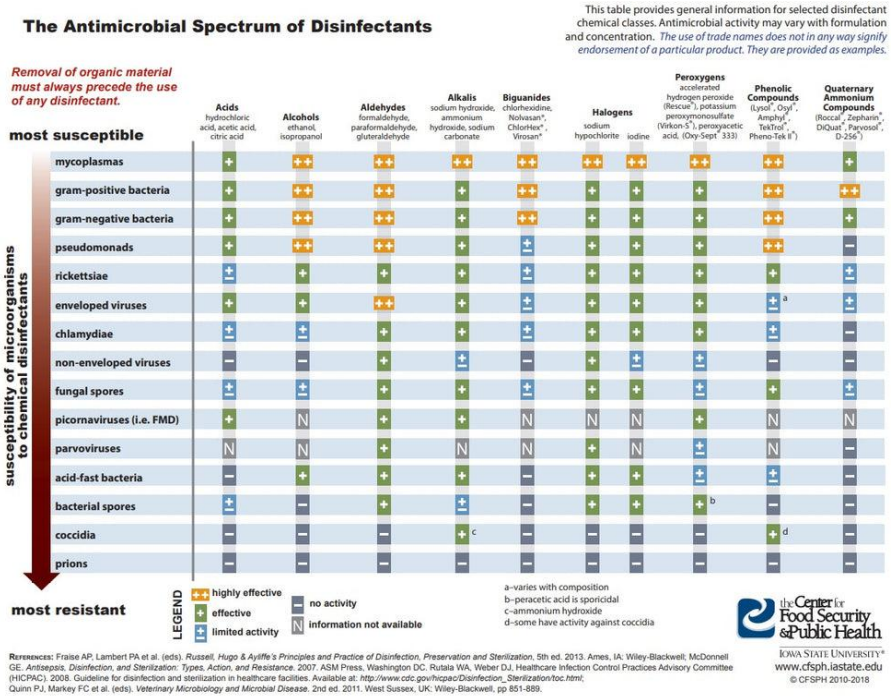

Figure (3) Disinfectants Comparation Chart

i. **Properties**: Each chemical agent has unique physical, chemical, and biological properties which are critical when choosing the right agent that suites the decontamination activity to accomplish best results and efficiency, these properties are[1]:

- Spectrum: An agent with wide antimicrobial spectrum is better.
- Safety: it refers to the level of toxicity and hazardous effects of the agent.
- Use-life: it means the length of time a diluted product can remain active and effective. The stability of the chemical and the storage conditions (e.g., temperature and presence of air, light, organic matter, or metals) determine the use-life of antimicrobial products.
- Stability: level of reactivity or flammability of the agent.

[1] Were taken from CDC and developed by the researcher.

- Shelf life: Length of time an undiluted or use dilution of a product can remain active and effective. Also refers to the length of time a sterilized product
- Speed acting: the period of time takes to start sanitizing.
- Penetration: the ability of penetrating infectious environment.
- Odor: the absence of scent or undesirable smell.
- Dyeing: causing stains on the surfaces or tissues.
- Environment: Environmental hazards, pollution and wild & aquatic life.
- Economical: should not be prohibitively high in cost
- Ease: the ease of use in storing, diluting and cleaning the agent.
- Compatibility: not corrode instruments and metallic surfaces and should not cause the deterioration of cloth, rubber, plastics, and other materials
- Security: chemical security and biosecurity restrictions of the agent.
- Cleaner: should have good cleaning properties
- Solubility: should be soluble in water.
- Residual effect on treated surfaces: should leave an antimicrobial film on the treated surface
- Stability: should be stable in concentrate and use-dilution.
- Validity: should be authorized, registered and certified quality.
- Environmentally friendly: should not damage the environment on disposal

j. **Resistance**:

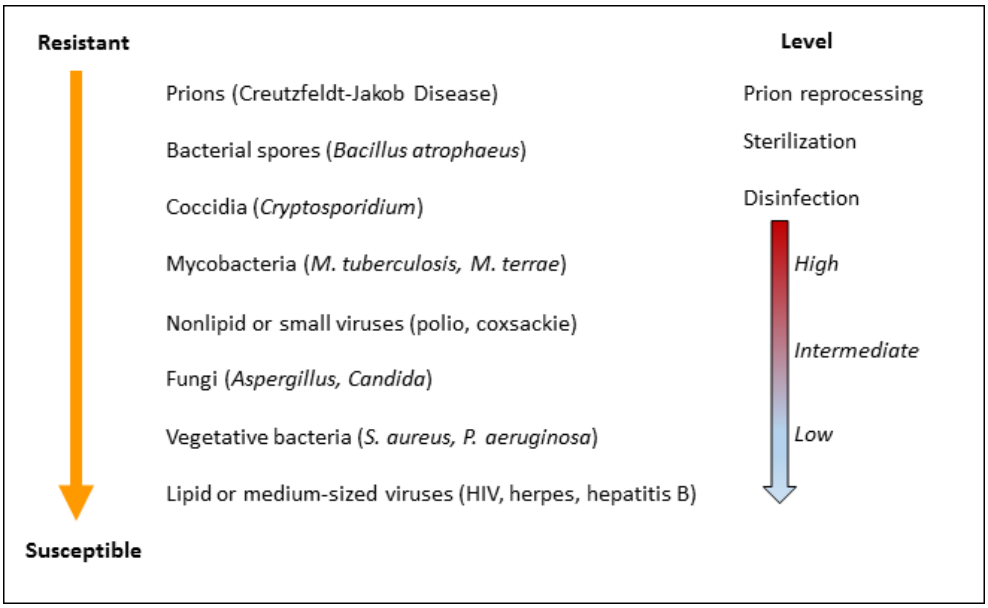

figure (4) micro-orgasms Resistance level from CDC [1]

1.3. Disinfectant Efficacy Testing: Disinfectant efficacy testing is the determination of biocidal effect of a disinfectant in the environment where the agent is used against particular organisms.

a. The AOAC:[2] Association of Official Agricultural Chemists (AOAC) and became AOAC International in 1991. It publishes standardized, chemical analysis methods designed to increase confidence in the results of chemicals and microbiological analyses.

[1] https://www.cdc.gov/infectioncontrol/guidelines/disinfection/tables/figure1.html

[2] AOAC International is a 501(c) non-profit scientific association with headquarters in Rockville, Maryland. It was founded in 1884 as the Association of Official Agricultural Chemists (AOAC) and AOAC International in 1991. It publishes standardized, chemical analysis methods designed to increase confidence in the results of chemical and microbiological analyses. Government agencies and civil organizations often require that laboratories use official AOAC methods. AOAC is headquartered in Rockville, Maryland, and has approximately 3,000 members based in over 90 countries

b. USP[1]: USP 1072 outlines three tests on effectiveness that may be necessary to conduct.

c. ASTM[2]: ASTM E1153 method is an antimicrobial test designed to determine the effectiveness of sanitizers on pre-cleaned, inanimate, potent, non-porous and non-food contact surfaces, [3] ASTM E1053 is an antimicrobial product test intended to determine the virucidal efficacy of antimicrobials on environmental surfaces

d. **EN:** EN 1276 standard specifies a suspension test for establishing whether a chemical disinfectant or antiseptic has bactericidal activity. Bactericidal suspension test (Standard: EN 1276: 1997) and Fungicidial suspension test (Standard EN 1650: 1998, surface test (Standards EN 13713: 1999 and EN 13697: 1999) and AOAC standard AOAC 991.47:1991 Hard surface carrier test method, Hand sanitization (Standard: EN 1500), EN 1040 to measure bactericidal activity and EN 1275 to measure fungicidal activity. The basic suspension test is a simple, limited test of the product and is performed in order to determine minimum standards. EN 13697 is a quantitative non-porous surface test that specifies the bactericidal and/or fungicidal activity of chemical disinfectants. This test is only for chemical disinfectants used in food, industrial, domestic, and institutional area, EN 14476 is a phase 2 step 1 suspension test to evaluate the virucidal activity of chemical disinfectants intended for use in the medical area, EN 1650:2019 - This document specifies a test method and the minimum requirements for fungicidal or yeasticidal activity of chemical disinfectants.

[1] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7831293/
[2] American standard testing materials.
[3] https://www.astm.org/e1052-20.html

e. ATCC: [1] Most disinfectants efficacy testing standards specifies the use of unique biological agent as a primary variable with specified strains for example: EN 1040 standard specifically identify using Pseudomonas aeruginosa ATCC 15442 and Staphylococcus aureus ATCC 6538, these strains are available at ATCC for purchase because it owns massive strains bank besides being globally certified standard reference institution. Which means any local authority must take the referenced sample form ATCC otherwise the standard test results credibility won't be accurate or reliable.

1.4. Efficacy testing methods:

Some of the methods used for efficacy testing are explained below:

a. **Manufacturing Protocols:** These protocols ensure the quality of manufacturing standards of components, concentration, and practices by strict supervision, monitoring and surveillance of manufacturing practices of the manufacturers.

b. Chemical Testing: It is done by executing Chemical analysis to conform the existence of the effective ingredient and its concentration, purity, stability and conforming the non- existence of harmful substances. This process requires advance laboratory equipment's as (HPLC Spectrometers, standard method, well trained workers, ensured conformity of results, equipment calibration, and availability of testing solutions.

[1] ATCC or the American Type Culture Collection is a nonprofit organization which collects, stores, and distributes standard reference microorganisms, cell lines and other materials for research and development. Established in 1925 to serve as a national center for depositing and distributing microbiological specimens, ATCC has since grown to distribute in over 150 countries. It is now the largest general culture collection in the world. Source: https://www.atcc.org/

c. **Biological efficacy testing:** Biological effectiveness test of the disinfectants is done to conform its efficacy which requires standard testing protocols, the availability of standard micro-orgasms with it (particular strains), the existence of microbial counting equipment, good laboratory practices, well trained workers, besides biosafety measures. **(Notes: in Yemen there are no Biological Bank, Genetic Research Centers)**

1. **Dilution method:** The dilution method involves adding a disinfectant to a specified concentration and exposing microorganisms to the disinfectant on a surface. The test evaluates the ability of the disinfectant to reduce the number of microorganisms within a specified time period. This method is commonly used in EPA and ASTM standards.
2. **Suspension test:** Suspension tests involve exposing microorganisms to the disinfectant in a liquid suspension. The test evaluates the ability of the disinfectant to reduce the number of microorganisms within a specified time period. This method is commonly used in EN and ISO standards.
3. **Carrier test:** Carrier tests involve applying the disinfectant to a surface and measuring its ability to reduce microbial populations over a specified time period. This method is commonly used in AOAC and CDC guidelines.
4. **Residual activity test:** Residual activity tests involve applying the disinfectant to a surface and measuring its ability to reduce microbial populations over a specified time period, typically 24 hours or longer. This method is commonly used in ISO standards.

2. Methods:

Research methodology followed in this study adopted the following procedures:

2.1. Scientifical Content: the theoretical content of this research was gathered from Internationally recognized parties and well trusted resources.

2.2. Yemen Healthcare Ranking: The global ranking and indicators were taken from the main issuer's reports to compensate the absence of national statistics. These indicators were specially chosen to address this research subject.

2.3. Yemeni Legislations study: The researcher has collected National laws of the republic of Yemen which were related to the research subject, then analyzing it in a comparative and descriptive approach.

2.4. Noticed practices in Yemen: The researcher used his own observations from the field as well as the dissection with specialized staff, also by collecting additional data from the internet and authorities' social pages.

2.5. Authorities' performance assessment:

The performance assessment of governmental authorities was executed by visiting each targeted authority and by asking these six questions:

k. Who is responsible for disinfectant efficacy testing?

l. What is the protocol of manufacturing?

m. What methods are followed to test disinfectant efficacy?

n. What equipment's used to implement chemical testing?

o. What standard do you follow to test disinfectant efficacy?

p. What standard biological agent and testing equipment you use?

By focusing: of Chloroxylenol[1] Testing standard[2] as a simple and a focus point.

2.6. Consumers questionnaire: The current study employs a simple questionnaire which aims to measure local practices of the customers in chemical disinfectant efficacy testing and measuring the opinion knowledge in this subject was designed by google forms and distributed randomly via WhatsApp and Facebook specialized groups in infection control, safety, healthcare personnel, medical & laboratory, and sent to persons in charge in health, environment ,and related quality and standardization authorities The questionnaire question was in Arabic translated to English in this research as follow:

Question	Options
- What is your scientific specialization?	Open
- Which department are you working in?	Controlled drop list - Medical laboratory/ healthcare - Industrial laboratory & quality - Governmental Supervision Authority - Scientific & academic laboratory - Chemical laboratory - Other
- Please write your department	Open
- Do you execute laboratory efficacy tests to disinfectants?	Yes/ NO
- What standards do you follow in choosing effective disinfectant agents?	- Controlled drop list - We don't - Original trademark - Being governmentally authorized - By its manufacturing certificates - Only by its price. - Assess after failure accrues

[1] Chloroxylenol is a famous kind of antiseptic known as (Dettol).
[2] Using EN 1040 Standard and HPLC Spectrometer to test the concentration of Effective ingredient.

Question	Options
	- Internal laboratory test - External laboratory test - Analyze on product data
- Who do you perform disinfectant efficacy test in laboratory (real practice):	Open
- Which authority responsible for testing efficacy of local and imported disinfectants?	Controlled choices - Public authority of specification, standards and Quality control - Supreme authority of medicine and medical instruments - General department of industrial mentoring - National center of public health laboratories
- On a scale of High to Low: how much do you trust the following: - Governmental authorities performance in testing disinfectants efficacy. - Quality & efficacy of locally made disinfectants. - Your own firm performance in disinfectants efficacy testing. - Quality& efficacy of imported disinfectants. - Quality& efficacy of disinfectants products having well-known trademarks. - Credibility of Yemeni laboratory tests.	The rate was in three levels: - High- medium- low
- Do you have any notes or questions? You can write your contact number so that the researcher can respond to your queries.	- Open

Table (1) the costumer questionnaire

The questionnaire was published on16th march 2023 for 20 days. The collected responses are (33), the collected data was analyzed statically in MS: Excel program.

2.7. Research difficulties:

a. Lack of national statistics.

b. Low questionnaire responses.

c. No funds for the current research.

3. Results:

3.1. Yemen Healthcare Ranking:

The following are the most famous global ranking and indicators which are strongly related to this research subject:

- **GHS**: Global Health security Index 2021 for Yemen is ranked 193 of 195 with a score of 16.1 (the average is 38.9), also ranked as last between 17 western Asian countries and 33 of 34 of low-income countries, more expanded indicators rates as the following table:

Cat	Indicators	Rate of 195	Percentage	Rank/Cat
1. Prevent	1.1. Antimicrobial resistance (AMR)	170	87%	192
	1.2. Zoonotic disease	144	74%	
	1.3. Biosecurity	114	58%	
	1.4. Biosafety	70	36%	
	1.5. Dual use research and culture if responsible science	13	7%	
	1.6. Immunization	182	93%	
2. Detect	2.1. Laboratory system strength and quality	155	79%	185
	2.2. Laboratory supply chains	58	30%	
	2.3. Real time surveillance and reporting	146	75%	
	2.4. Surveillance data accessibility and transparency	170	87%	
	2.5. Case based investigation	95	49%	
	2.6. Epidemiology workforce	122	63%	
3. respond	3.1. Emergency preparedness and response planning	181	93%	194
	3.2. Exercising response plans	154	79%	
	3.3. Emergency response operation	145	74%	
	3.4. Linking public health and security authorities	44	23%	

Cat	Indicators	Rate of 195	Percentage	Rank/Cat
	3.5. Risk communication	103	53%	
	3.6. Access to communications infrastructure	191	98%	
	3.7. Trade and travel restrictions	15	8%	
4.Health	4.1. Health Capacity in clinics, Hospitals and Community care centers	179	92%	167
	4.2. Supply chain for health system and Healthcare workers	152	78%	
	4.3. Medical countermeasures and personnel deployment	37	19%	
	4.4. Healthcare access	88	45%	
5. Norms	4.5. Communications with Healthcare workers during Emergency	33	17%	153
	4.6. Infection control practices and availability of equipment	80	41%	
	4.7. Capacity to test and approve new medical countermeasures	120	62%	
	5.1. IHR reporting compliance and disaster risk reduction	49	25%	
	5.2. Cross-border agreements on public health and animal health emergency response	137	70%	
	5.3. International commitment	74	38%	
	5.4. JEE and PVS	110	56%	
	5.5. Financing	90	46%	
	5.6. commitment to sharing of genetic & biological data & specimens	12	6%	
6. Risk	6.1. Political and security risk	194	99%	194
	6.2.Socio- economic resilience	183	94%	
	6.3.Infestracture adequacy	190	97%	
	6.4.Environmental risk	136	70%	
	6.5. Public health vulnerability	164	84%	
Yemen Global Ranking		**193**/195		

Table (2) GHS ranking of Yemen in 2021[1]

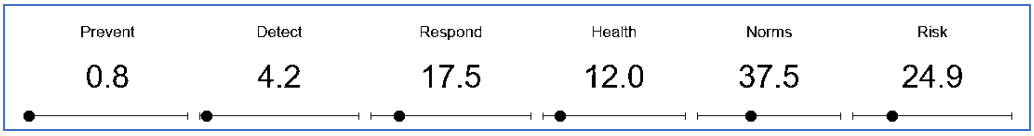

Diagram (2) GHS ranking of Yemen in 2021 Graphically shows Yemen's status in each Category

[1] Source: www.GHSindex.org

- **World bank**: in 2021 Yemen is ranked **193** of 195[1]
- **WHO- EMRO**: in 2021 Yemen is ranked **155** of 156. [2]
- **HDI**: Yemen ranks **179** out of 189 on the Human Development Index.
- Transparency International 2021 Corruption Perceptions Index ranked **176** out of 179.
- **Good Country Index**: 2017, ranked **160** out of 163
- **BTI**: Yemen Country Report 2022 Ranks Yemen the **Last** of 137. [3]
- **WHR**: World Health ranking of Yemen in 2023 has a lot of data, the researcher choose cancers and infectious diseases indicators as it the most relevant to this research's subject as follows:

Top 50 Causes of Death			
Causes	**World Rank**	**Causes**	**World Rank**
Influenza and Pneumonia	63	Cervical Cancer	**178**
Lung Disease	49	Hepatitis B	**7**
Kidney Disease	95	Poisonings	46
Liver Disease	84	Oral Cancer	77
Asthma	26	Endocrine Disorders	118
Diabetes Mellitus	120	Uterin Cancer	**181**
Diarrhoeal diseases	64	Bladder Cancer	129
Tuberculosis	68	Pertussis	26
Congenital Anomalies	29	Ovary Cancer	**166**
Oesophagus Cancer	24	Pancreas Cancer	134
Colon-Rectum Cancers	107	Lymphomas	**168**
Peptic Ulcer Disease	30	HIV/AIDS	107
Oesophagus Cancer	24	Liver Cancer	102
Measles	**12**	Lung Cancers	137
Leukemia	101	Skin Cancers	**144**
Oral Cancer	77	Prostate Cancer	**183**
Pancreas Cancer	134	Stomach Cancer	67
Lymphomas	**168**	Colon-Rectum Cancers	107

Table (3) World Health Ranking 2023[1]of the Top 50 Causes of Death

[1] Source: www.devex.com ,
[2] Source: www.emro.who.int
[3]Source: https://bti-project.org/en/reports/country-report/YEM

The analysis of Yemeni global ranking indicators justifies and proves low performance of disinfectants efficacy testing and low awareness of chemical disinfectants using poor healthcare and standardization procedures of national performance which in turn justifies the high cases of cancers and infectious diseases.

3.2. National Legislations & Authorities Performance:

a. Legislations:

There are many laws related to the research topic see [27], a conflict of specialization was noted between public authority of specification, standards and Quality control and, public authority of specification, standards and Quality control - Supreme authority of medicine and medical instrument, and National center of public health laboratories besides Occupational safety& Health and public authorities for Environment protection, in the field standardization, licensing, waste management.

Moreover, there are no national standards of disinfectants testing. Analyzing the Ministry of Health guides [13] showed the absence of disinfection standards or testing.

b. Authorities Performance:

Authority/ Questions	Public Authority of Specification, Standards and Quality Control (1)	Supreme Authority of Medicine and Medical Instrument (2)	National Center of Public Health Laboratories: (3)	Public authorities for Environment protection (4)	General Department of Industrial surveillance (5)
Who is responsible of disinfectant efficacy testing?	(1) & (2)	(1) & (2)	(1) & (2) & (3)	(1) & (2)	(1) & (2)
What is the protocol of manufacturing you use?	No standard	No standard	Not relevant	Not relevant	Not relevant

[1] Source: https://www.worldlifeexpectancy.com/country-health-profile/yemen

Authority/ Questions	Public Authority of Specification , Standards and Quality Control (1)	Supreme Authority of Medicine and Medical Instrument (2)	National Center of Public Health Laboratories : (3)	Public authorities for Environment protection (4)	General Department of Industrial surveillance (5)
What methods are followed to test disinfectant efficacy?	Chemical & Biological & GMP & Safety certificates of materials	GMP & Safety certificates of materials	Biological test	Not relevant	Not relevant
What equipment used to implement chemical testing?	Basic tools, no standards, lack of suitable equipment like HPLC spectrometer	Basic tools, no standard, lack of suitable equipment like HPLC spectrometer	Basic tools, no standards, lack of suitable equipment like HPLC spectrometer	Basic tools, no standards, lack of suitable equipment like HPLC spectrometer	Not relevant
What standard biological agent and testing equipment you use?	No specific strains. No macro-orgasms counting device available	No specific strains No macro-orgasms counting device available	No specific strains No macro-orgasms counting device available	No specific strains No macro-orgasms counting device available	Not relevant
Response came from:	The Source preferred not to be mentioned	The Source preferred not to be mentioned	GM& Quality Manager	Authority President	Industrial Mentoring G. Manager
Response collected Via	Field visit+ calling & text	Calling	Field visit+ calls	Call	call
Evaluation	**Poor**	**Weak**	**Weak**	**Poor**	**Weak**

Table (4) Assessment of Governmental authorities performance

3.3. Noticed practices in Yemen:

The Covid-19 pandemic in 2020 was like a milestone in disinfection aspect worldwide and in Yemen as well. During this period and after that the focus on disinfectants and its efficacy grew rapidly specially after the Yemeni health renaissance of infection control and the big lapse accomplished in healthcare quality besides the huge funding of health system by the

international organizations to face catastrophic Infectious diseases that spread in Yemen from 2015 till the moment.

In addition, many poor practices were noticed by the researcher such as:

- Using chlore as an antiseptic via spraying people with it and as portal decontamination spray.
- The use of harmful products such as methanol or ammonia compounds.
- Using gentian (i.e. blue dyes) though it is scientifically proven to cause skin cancer.
- Using toxic compounds in pottery water filters (silver nitrate).
- Many products produced locally and violated copyright laws and were confiscated by authorities.
- Low awareness of occupational and Environmental safety
- The spread of smuggled medical products.
- The absence of medical waste management [9].
- The high prices of disinfectants conjugate with increased taxes.
- The government stopped funding governmental healthcare facilities.
- The corruption of governmental authorities.[1]
- The absence of safety curricula in Yemeni Universities.[10]

3.4. Costumers' practices and views:

a. The questionnaire results indicate that most of Costumers % 61.5 don't execute laboratory tests of chemical disinfectants, and the few who dose have no standards of testing.

b. the standards used to choose between different disinfectants to determine its efficacy is described in the following table:

[1] according to CPI corruption indicator 2022 source: www.tranparancy.org

What standards do you follow in choosing effective disinfectant agents?

By what standard you between different disinfectants to determine its efficacy?	
We don't	15%
Original trademark	27%
Being governmentally authorized	6%
By its manufacturing certificates	6%
Only by its price.	6%
Assess after failure accrues	6%
Internal laboratory test	21%
External laboratory test	1%
Analyze on product data	9%

Table(5) summary of costumers questionnaire results

c. With regard to the laboratory test procedures performed to disinfectant efficacy testing, no results described following any international standards.

d. The costumers' awareness about the specialized authorities of disinfectant efficacy is highlighted in the table below: Which authority responsible for testing efficacy of local and imported disinfectants?

Who is the authority responsible of testing national and imported disinfectant efficacy?	
Public authority of specification, standards and Quality control	68%
Supreme authority of medicine and medical instruments	21%
General department of industrial mentoring	3%
National center of public health laboratories	6%

Table (6) describes the costumers' opinions of specialized authority.

e. The costumers trust assessment part results as follows:

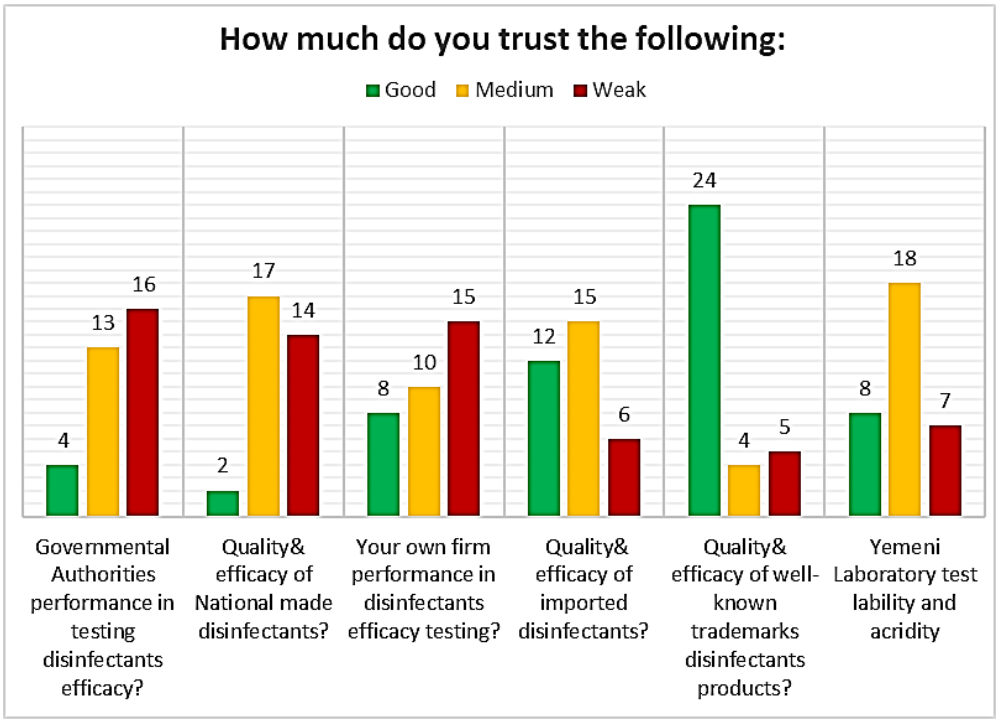

Chart (1) of the costumer's trust assessment results.

4. Discussions:

a. The analysis shows clear evidence of high rate of illnesses in Yemen due to the lack of adherence to the international standards in manufacturing and testing of disinfectants.

b. Low rate of costumers' trust in governmental performance and Yemeni products.

c. Poor governmental authorities' performance and its qualifications with conflict of responsibilities.

d. Poor national performance and awareness in infection control practices.

5. Conclusion:

The results of this research indicates that Yemen practices of chemical disinfectants & antiseptics agents efficacy testing is extremely poor and do not follow any international practices, which raises an alarm that Yemen will continue suffering of disastrous impacts due to the lack of standards and poor governmental and scientific performance in the fields of healthcare, infection control, occupational and environmental safety. In addition, Yemen will be a contagious zone which may cause a threat to the neighboring countries. Furthermore, low trust in locally produced products could lead to weak demand which leads to industrial and trading failures and difficulties.

6. Recommendations:

The following suggestions can improve the quality of disinfectants and their safety in the Yemeni context:

a. Adhering to international standards is very important which in turn improves the current situation of the disinfectants in Yemen.

b. Planning and implementing a complete and effective strategies of infection control and healthcare, starting with real assessment of governmental resources, human resources qualifications, analyzing the conflict of specializations and improving laboratories equipment.

c. The results of this research must be studied and discussed in scientific conferences and workshops and its recommendations must reach government authorities.

d. The researcher believes that fixing similar issues cannot be done with or by the same corrupted and inefficient governmental personnel, it is important to renew the working force with new qualified personnel.

e. The researcher highly suggests establishing a Central National Institute of Health, Safety & Environment for Standardization and Researches

which will be responsible of creating protocols, standards, policies, procedures, manuals. Some of the tasks that can be assigned to this institute include: working as a central advanced laboratory aided by a biological bank that is enriched with data, specimens, besides being general research facility to solve all manufacturing, health, safety, environment and scientific research issues in Yemen.

f. According to the Yemeni national low, the Public Authority of Specification, Standards and Quality Control, is the responsible party for testing and permitting all relevant products. This law must be enacted and never be overcome by other parties.

g. It is crucial to implement further researches in this area of study.

7. Appreciation:

For Al-Hadharah University for publishing this research in its scientific Journal

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تقييم فعالية مواد التطهير والتعقيم بين المعايير الدولية والممارسات الفعلية وتقييم اداء الجهات المعنية في اليمن

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الملخص:

يهدف البحث إلى توضيح المطهرات والمعقمات الكيميائية وخصائصها، مع التركيز على المعايير الدولية لاختبار فاعليتها كمقدمة لدراسة الممارسات الفعلية وتقييم الأداء في اليمن في اتباع المعايير الدولية لاختبار فاعلية المواد التطهير. وتم وذلك باستخدام المنهج التحليلي الوصفي لتحليل التشريعات الوطنية، ومقابلة موظفي الجهات ذات الصلة، ونتائج استبيان قياس الممارسات الحقيقية للمستهلكين لاختبار فاعليتها. تشير نتائج البحث إلى غياب بروتوكول تصنيع وطني وعدم اتباع أي معايير دولية ذات صلة بسبب غباب الموارد اللازمة لتطبيق هذه المعايير الدولية، مما يبرر ضعف أداء مكافحة العدوى وانتشار الأمراض وانخفاض ترتيب اليمن عالميًا . وبسبب مواصفات المطهرات الكيميائية غير الموثوقة وإجراءات التصريح الغير صحيحة عن المنتج الغير مطابق بسبب عدم اتباع المعايير الدولية ذات الصلة لاختبار فاعليتها. تكشف نتائج استبيان إضافي عن انخفاض ثقة المستهلكين في أداء السلطات الحكومية ذات الصلة وانخفاض ثقتهم بمنتجات المطهرات اليمنية. وفي الختام تم تقديم مجموعة من التوصيات لمعالجة هذه القضية وعلى وجه الخصوص إنشاء المركز /المعهد الوطني اليمني للصحة والسلامة والبيئة.

الكلمات المفتاحية: الصحة في اليمن، مكافحة العدوى، قياس فعالية المطهرات، المعايير الصناعية، المواصفات اليمنية

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