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Microbial Contamination of Open-But-Unused Portions of Wound Dressings in Healthcare Facilities

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ABSTRACT

To assess the potential for microbial contamination of open-but-unused portions of wound dressings stored under real-life conditions in healthcare facilities, to inform safer and evidence-based wound care practices. Observational, descriptive, longitudinal, prospective study. Eleven types of non-adhesive wound dressings were sampled after opening and storage under usual clinical conditions in a hospital inpatient unit and a primary care centre in Andalusia, Spain. Samples were collected on six predefined sampling days (Days 0, 2, 3, 4, 5 and 6 after opening), cultured under standardised laboratory conditions and microorganisms were identified using mass spectrometry. Differences in contamination were examined by dressing type, healthcare setting, storage time and handling conditions. Microbial growth was frequently detected in open-but-unused dressings from the first day after opening, particularly after enrichment culture and increased with handling and time. The most frequent microorganisms were coagulase-negative staphylococci and *Staphylococcus aureus*. Contamination patterns were similar across settings, although microbial diversity was higher in the hospital. Silver-containing dressings showed slightly lower contamination, but not enough to indicate protection. Scissors used for cutting dressings had high microbial loads, suggesting a potential source of cross-contamination. Open-but-unused dressings may become contaminated shortly after opening under routine clinical practice conditions, across different healthcare settings and dressing types.

1 | Introduction

Wound care is a fundamental nursing activity. Within this field, the reuse of open-but-unused portions of wound dressings is a relatively common practice in chronic wound care, despite warnings from manufacturers and health regulators. Most advanced wound dressings are single-use, with labels which indicate that they should not be reused and that any unused leftovers should be disposed of to avoid the risk of infection or cross-contamination.

However, recent studies carried out in Spain suggest that more than 89% of nurses have reused leftover wound dressing scraps for economic or supply reasons, even though 95% acknowledge that this may pose a risk of infection [1, 2]. This discrepancy between wound care recommendations and actual clinical

Reporting Method: The study was reported in accordance with the STROBE statement for observational studies, and the STROBE checklist corresponding to a longitudinal observational design was completed and submitted as Supporting Information.

Summary

- The findings highlight the need to review wound care protocols, avoid reuse of leftover dressings and promote sterile single-use products. Cutting tools should be disinfected or replaced after each use.
- What problem did the study address? The reuse of open-but-unused wound dressings despite infection risk
- What were the main findings? Early and widespread microbial contamination of stored dressings and cutting tools.
- Where and on whom will the research have an impact? On nurses and wound care professionals in hospital and primary care settings.
- What does this paper contribute to the wider global clinical community?
    - Provides evidence of contamination in reused wound dressings.
    - Emphasises strict handling and single-use materials.
    - Supports safer, evidence-based wound care nursing practices.

practice has prompted multiple studies on the potential for microbiological contamination of open-but-unused dressings and the conditions for their safe use.

Several studies have examined different types of dressings and wound care supplies to determine their susceptibility to contamination after the package has been opened. Non-sterile wound care supplies and adhesive tape [3], advanced dry and moist wound dressings [4], hydrogels [5] and antimicrobial dressings [6] have been assessed. Previous studies generally indicate that the risk of contamination is low when storage and handling are adequate but that the risk of contamination increases if dressings are stored under inadequate conditions or handled without aseptic technique.

Some studies have assessed contamination of open-but-unused wound dressings and wound care supplies under various handling, time and environmental conditions. They found differences in the contamination rates between hospital and home settings, immediate exposure and prolonged storage and showed increasing contamination after the first week if strict protocols were not followed, whereas open-but-unused wound dressings showed similar levels of contamination to new dressings when kept in controlled environments [6].

A study by Berkowitz et al. [7] on the use of adhesive tape in the intensive care unit showed contamination in tape rolls (which remained in treatment carts or next to the patient during routine use). Bacterial growth was detected within the first 24 h of use, with increasing colonisation over time. Although no infections directly attributed to these contaminated adhesive tapes were documented, the authors of this seminal study warned about the potential of adhesive tapes to act as a source of nosocomial infection through cross-contamination.

Other prospective studies have simulated the common practice of saving the remainder of a wound dressing for later use at home. Zwanziger and Roper [8] investigated open-but-unused wound care supplies in assisted-living facilities; collecting samples on Days 1, 7 and 14 after the supplies were opened. They found that bacterial contamination became evident after the first week and increased in the second week. By Day 14, 75% of the wound care supplies showed microbial growth, with bacterial load and diversity increasing over time.

The most frequently detected pathogens in these studies included gram-positive bacteria such as *Staphylococcus aureus*, coagulase-negative staphylococci (CoNS) and enterococci; gram-negative bacteria such as *Pseudomonas aeruginosa*, *Escherichia coli* and *Proteus* spp.; and occasionally fungi such as *Candida* spp.

Recently published papers acknowledged that current evidence is insufficient to make definite recommendations on the suitability of reusing portions of wound dressings. Available reviews [9], including a 2024 systematic review [1, 2], have concluded that although reuse occurs as a result of factors such as a lack of customised presentation or the perceived scarcity of resources, evidence on the safety of this practice in terms of microbial contamination is lacking. Given this uncertainty, the precautionary principle that leftover dressings should be discarded and that sterile, single-use supplies should be used whenever the clinical setting allows prevails.

This study, conducted as the third phase of a larger project, aimed to assess the potential for microbial contamination of open-but-unused dressings stored under real-life working conditions in healthcare facilities, to provide evidence to support clinical decision-making and the development of recommendations based on patient safety.

The main objective of this study was to assess the incidence of microbial contamination in open-but-unused portions of wound dressings and its evolution over time, according to the type of healthcare setting, type of dressing and factors related to their handling.

2 | Material and Methods

2.1 | Study Design and Setting

This study was designed as an observational, descriptive, longitudinal, prospective study aimed at assessing microbial contamination of open-but-unused portions of wound dressings under routine clinical practice conditions.

The study was conducted in two healthcare settings located in a city in Andalusia, southern Spain:

1. an internal medicine inpatient unit of a tertiary-level university hospital and
2. a primary care health centre providing outpatient wound care services.

Both settings routinely manage patients with chronic wounds and commonly use non-adhesive dressings that require cutting to fit wound dimensions. The study sought to reproduce typical real-life handling, storage and reuse practices observed in these settings, rather than imposing standardised experimental conditions.

Data collection took place between November and December 2024. No changes to routine clinical workflows were introduced during the study period, except for the collection of dressing samples for microbiological analysis.

2.2 | Sampling and Dressing Selection

A purposive sampling strategy was used to select wound dressings that are routinely cut and partially reused in chronic wound care in the participating healthcare settings.

Eleven types of non-adhesive, sterile wound dressings were included in the study. These dressings represent the most frequently used products in the chronic wound care formularies of the Andalusian Health Service in both primary care and hospital settings. All selected dressings required cutting to adapt their size to the wound and were supplied in formats that allow partial use. An additional sample corresponding to the scissors used to cut the dressings was included to assess potential cross-contamination.

The characteristics of the included dressings, such as material category, absorbency and presence or absence of silver, are summarised in Table 1. To minimise analytical bias, dressings were anonymised using letter codes (A–K) during sample processing and microbiological analysis. Silver-containing dressings were identified by codes C, E and H; however, laboratory personnel were unawere of to the antimicrobial status of the dressings.

For each dressing type and healthcare setting, one dressing pack was opened and stored under routine clinical conditions. Repeated samples were obtained longitudinally from the same opened pack over time. Six samples per dressing type and setting were collected on predefined sampling days (Days 0, 2, 3, 4, 5 and 6 after opening). Each sample consisted of a 1×1 cm portion cut from the remaining unused dressing.

This approach resulted in repeated within-pack observations across time rather than independent samples. The study was therefore designed to explore temporal patterns of contamination under real-life conditions, rather than to estimate independent contamination probabilities for individual dressings.

2.3 | Storage and Handling Conditions Under Routine Clinical Practice

After opening, dressing packs were stored and handled according to routine clinical practice in each healthcare setting, without introducing any additional standardisation or experimental controls. The aim was to reflect usual real-life conditions under which open-but-unused dressings are commonly stored and reused in daily wound care.

In both settings, dressings were opened by nursing staff during routine wound care procedures and subsequently stored in their original packaging, which remained partially open, or placed inside a clean, non-sterile container or drawer commonly used for wound care materials. Storage locations included treatment rooms, wound care trolleys, or designated clinical drawers, depending on local practice in each unit.

Dressings were stored at ambient room temperature. No specific controls regarding temperature or humidity were applied, and environmental conditions were those typical of clinical indoor settings. The opened dressing packs could be accessed multiple times per day, depending on clinical workload and wound care activity.

Handling of dressings was performed by nursing staff as part of routine care. Hand hygiene and glove use followed standard institutional policies, but no additional aseptic field or sterile technique beyond usual practice was enforced for the purposes of the study. The frequency of handling and the number of healthcare professionals accessing each opened pack were not restricted, reflecting real-world variability.

Cutting of dressings was performed using the scissors routinely available in each clinical setting. These scissors were not assigned exclusively to the study and were used as part of standard clinical practice. No systematic disinfection protocol was implemented between uses beyond usual local practice.

This pragmatic approach was chosen to maximise ecological validity and to capture the cumulative effect of routine storage, repeated handling and environmental exposure on microbial contamination of open-but-unused dressings.

2.4 | Sample Collection and Microbiological Procedures

Sample collection was performed by trained nursing staff following a predefined protocol based on previously published methodologies for assessing contamination of wound care supplies developed by Zwanziger and Roper [8]. At each sampling time point, a 1×1 cm portion was cut from the remaining unused area of each opened dressing using the scissors routinely available in the clinical setting.

Each dressing sample was immediately placed into a sterile tube containing 2 mL of thioglycolate broth (Becton, Dickinson, USA). Thioglycolate broth was selected as a liquid enrichment medium to enhance the detection of low-level microbial contamination that might not be detectable by direct plating alone, particularly given the characteristics of the samples and their handling constraints, which required maximising diagnostic yield.

At the same time points, a swab sample was collected from the surface of the scissors used to cut the dressings. The swab was introduced into a separate tube containing thioglycolate broth

TABLE 1 | Characteristics of the wound dressings included in the study.

Dressing code	Commercial name	Dressing category/material	Woven/non-woven	Absorbency	Antimicrobial component	Sterility status	Typical clinical use
A	Aquacel Foam	Hydrocolloid foam dressing	Non-woven	High	None	Sterile	Moderate to highly exuding wounds
B	Aquacel Extra	Hydrocolloid hydrofibre	Non-woven	High	None	Sterile	Exuding chronic wounds
C	Aquacel Extra Ag	Hydrocolloid hydrofibre	Non-woven	High	Silver	Sterile	Exuding wounds with suspected infection
D	Urgoclean	Polyacrylate micro-adherent fibre (hydrodetersive)	Non-woven	High	None	Sterile	Sloughy or fibrinous wounds
E	Urgoclean Ag	Polyacrylate micro-adherent fibre (hydrodetersive)	Non-woven	High	Silver	Sterile	Sloughy wounds with infection risk
F	UrgoStart	Non-adhesive lipid-colloid matrix	Non-woven	Moderate	None	Sterile	Chronic wounds with delayed healing
G	Biatain Alginate	Calcium alginate	Non-woven	Very high	None	Sterile	Highly exuding wounds
H	Biatain Alginate Ag	Calcium alginate	Non-woven	Very high	Silver	Sterile	Highly exuding infected wounds
I	Mepilex Lite	Thin polyurethane foam	Non-woven	Low–moderate	None	Sterile	Low-exudate or superficial wounds
J	Allevyn	Polyurethane foam	Non-woven	Moderate–high	None	Sterile	Moderate to high exudate wounds
K	Mepitel	Silicone wound contact layer	Non-woven	Minimal	None	Sterile	Atraumatic contact layer for fragile wounds

and processed following the same microbiological workflow as the dressing samples.

Upon receipt in the microbiology laboratory, samples were processed using a two-step culture approach. First, 100 μL of the thioglycolate broth was inoculated onto a blood agar plate and incubated under aerobic conditions at 35°C for 96 h. This initial culture was defined as the direct culture (DC) and aimed to detect microorganisms present at the time of sampling, representing contamination proximal to potential clinical exposure.

After inoculation for DC, the remaining broth containing the dressing fragment or scissor swab was incubated at 35°C under aerobic conditions for 24 h to allow microbial enrichment. Following this incubation, a second 100 μL aliquot was inoculated onto a blood agar plate and incubated under the same conditions (35°C, aerobic atmosphere, 96 h). This second culture was defined as the passage culture (PC) and was intended to increase sensitivity for detecting low-level bioburden.

Plates were examined at 24-h intervals (24, 48, 72 and 96 h). Colony-forming units (CFUs) were quantified at each reading, and final counts were established at 96 h to ensure detection of slow-growing microorganisms. When discrete colonies were present, CFU per millilitre (CFU/mL) was calculated using the formula: CFU/mL = (number of colonies counted × dilution factor)/plated volume (mL). As 100 μL (0.1 mL) of broth were plated, each colony corresponded to 10 CFU/mL. Therefore, the predefined operational threshold of > 200 CFU/mL corresponded to > 20 colonies per plate. Growth exceeding 200 CFU/mL was operationally defined as a positive result, corresponding to ≥ 10 CFU per plate, in accordance with the guidelines of the Spanish Society of Infectious Diseases and Clinical Microbiology [10].

Direct culture (DC) provided quantitative contamination data reflecting microbial load at the time of sampling, whereas passage culture (PC) primarily enhanced qualitative detection through enrichment, increasing sensitivity for low-level bioburden.

In cases of mixed growth, each morphologically distinct colony type was recorded and subcultured separately for identification. Quantitative contamination analyses were conducted at the sample level (presence or absence of significant growth per sample). Microorganism distribution was reported at the isolate level, as each morphologically distinct colony type was identified and recorded separately.

Coagulase-negative staphylococci (CoNS) were not systematically subcultured unless considered clinically significant.

Microorganisms were identified using matrix-assisted laser desorption/ionisation time-of-flight (MALDI-TOF) mass spectrometry according to standard laboratory procedures.

Only aerobic cultures were performed, as the primary objective of the study was to assess environmental and handling-related contamination rather than to characterise the full anaerobic microbiota of chronic wounds. In addition, dressings and scissors were continuously exposed to ambient air during storage and routine clinical handling. Prolonged oxygen exposure markedly reduces the viability of strict anaerobes; therefore, anaerobic culture was considered unlikely to yield clinically meaningful isolates under these conditions.

Laboratory procedures were carried out by trained microbiology personnel blinded to dressing type, presence of silver, healthcare setting and sampling day. Standard laboratory quality control procedures routinely applied in the participating microbiology laboratory were followed throughout the study; no additional study-specific negative controls were introduced.

2.5 | Statistical Analysis

Data analysis was primarily descriptive and exploratory in nature, reflecting the observational design and the real-life conditions under which the samples were obtained.

Categorical variables were summarised using frequencies and percentages, and continuous variables were summarised using means and standard deviations (SD), or medians and interquartile ranges when appropriate. Normality of continuous variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests.

Comparisons between groups were performed using independent-samples *t*-tests or Mann–Whitney *U*-tests for continuous variables, and chi-square or Fisher's exact tests for categorical variables, as appropriate. These analyses were intended to explore patterns and trends rather than to support causal inference.

Direct culture (DC) and passage culture (PC) results were derived from the same samples and therefore represent paired observations. Given the exploratory objectives of the study and the limited number of dressing packs per group, formal paired or mixed-effects modelling was not undertaken. This limitation was taken into account in the interpretation of results, and findings are presented primarily as descriptive comparisons.

Repeated measurements obtained from the same dressing packs over time were acknowledged as longitudinal within-pack observations rather than independent samples. No adjustments were made for intra-pack correlation, and this was considered when interpreting *p*-values and effect estimates.

All statistical analyses were performed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Statistical significance was set at $p < 0.05$. Where relevant, emphasis was placed on the magnitude and direction of observed differences rather than solely on statistical significance.

2.6 | Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and with all relevant national regulations pertaining to biomedical research and data protection. The study was approved by the Cádiz Research Ethics Committee in January 2024 (reference number: SICEIA-2024-000277). The study involved the microbiological analysis of wound dressings and cutting scissors collected under routine clinical practice and did not include any intervention on patients, collection of identifiable personal data, or modification of standard care. Therefore, no informed consent from patients was required, in accordance with the ethics committee's guidance.

3 | Results

3.1 | Sample Overview and Overall Culture Positivity

A total of 286 samples were collected during the study period. Of these, 142 corresponded to direct cultures (DC) and 144 to passage cultures (PC) obtained after 24-h enrichment. Results were missing for two DC samples due to technical issues during processing.

Overall, microbial growth was detected in 185 of the 286 samples (64.7%) at some point during the culture process. Positivity rates differed markedly between DC and PC samples. A total of 48 DC samples (33.8%) showed growth exceeding the predefined operational threshold, whereas 137 PC samples (95.1%) were positive following enrichment.

This difference reflects the higher sensitivity of enrichment culture for detecting low-level microbial presence. Accordingly, DC results are interpreted as more closely representing contamination detectable at the time of sampling, whereas PC results indicate the presence of microorganisms detectable after enrichment.

Microbial growth was observed in DC samples from the initial sampling day (Day 0), indicating that detectable contamination was present shortly after opening the dressing packs. Across subsequent sampling days, the proportion of positive PC samples remained consistently high, whereas DC positivity showed greater variability over time.

Table 2 summarises the number of samples with significant microbial growth according to sampling day and culture type.

TABLE 2 | Number of contaminated samples according to the day of collection.

	Number of samples with significant growth		
Collection time	**DC**	**PC**	**Total number of samples**
Day 0	16	23	39
Day 2	0	22	22
Day 3	11	24	35
Day 4	12	23	35
Day 5	4	24	28
Day 6	5	21	26

Abbreviations: DC, direct culture; PC, passage culture.

3.2 | Microorganisms Identified

A total of 185 samples showed microbial growth during the study period, either in direct culture (DC) or after enrichment in passage culture (PC). The distribution of microorganisms identified across all positive samples is presented in Table 3.

Coagulase-negative staphylococci (CoNS) were the most frequently isolated microorganisms, accounting for 77% of all contaminated samples. *Staphylococcus aureus* was the second most commonly identified microorganism, detected in 17% of positive cultures. Other microorganisms were identified less frequently and included *Neisseria* spp., *Actinomyces* spp., *Escherichia coli*, *Bacillus* spp., *Pseudomonas* spp., *Serratia* spp. and *Streptococcus* spp.

The predominance of CoNS was consistent across sampling days, healthcare settings and dressing types. These microorganisms were detected both in DC and PC samples, although their detection frequency was higher in PC samples, reflecting the increased sensitivity of enrichment culture.

Potentially pathogenic microorganisms, including *Staphylococcus aureus* and Gram-negative bacilli, were detected less frequently than CoNS but were present in both healthcare settings and across multiple sampling days. Their identification indicates that contamination associated with routine handling and storage was not limited to commensal skin flora.

Mixed microbial growth was observed in a minority of samples. When present, all morphologically distinct colonies were identified and recorded. No systematic differences in microorganism distribution were observed between dressing types at this descriptive level of analysis.

3.3 | Differences According to Healthcare Setting

Of the 185 samples that showed microbial growth, 103 (55.7%) were obtained from the hospital setting and 82 (44.3%) from the primary care setting. When considering all samples collected in

TABLE 3 | Microorganisms identified in the contaminated samples.

Microorganism	*n*	%
CoNS	142	77
Staphylococcus aureus	32	17
Neisseria spp.	4	2
Actinomyces spp.	2	1
Escherichia coli	2	1
Bacillus spp.	1	1
Pseudomonas spp.	1	1
Serratia spp.	1	1
Streptococcus spp.	1	1

Abbreviation: CoNS, coagulase-negative staphylococci.

each setting, 72% of hospital samples and 57% of primary care samples showed evidence of microbial growth at some point during the culture process (Table 4).

Differences between healthcare settings were more pronounced in direct cultures (DC) than in passage cultures (PC). In DC samples, a higher proportion of positive cultures was observed in the hospital setting compared with primary care across several sampling days. In contrast, PC positivity rates were consistently high in both settings throughout the study period, with more than 90% of samples showing growth after enrichment (Table 5).

Temporal patterns differed slightly between settings. In the primary care setting, no microbial growth was detected in DC samples on Days 2 and 3, whereas DC positivity in the hospital setting was observed from Day 0 and persisted across most sampling days. From Day 4 onwards, DC positivity increased in both settings. These findings suggest greater variability in detectable contamination over time in primary care, whereas contamination in the hospital setting appeared more consistent across sampling days.

The distribution of microorganisms identified differed between settings (Table 6). Coagulase-negative staphylococci remained the predominant isolates in both contexts. However, *Staphylococcus aureus* was identified more frequently in samples from the hospital setting than from primary care. Specifically, *S. aureus* was detected in 29 hospital samples (27.4%) compared with three primary care samples (3.8%), a difference that reached statistical significance ($p < 0.001$) (Figure 1).

TABLE 4 | Distribution of positive samples by setting.

	Day 0		Day 2		Day 3		Day 4		Day 5		Day 6		
	DC	**PC**	**DC**	**PC**	**DC**	**PC**	**DC**	**PC**	**DC**	**PC**	**DC**	**PC**	**Total**
	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***N* (%)**
Primary care	4	11	0	10	0	12	6	11	2	12	3[a]	11	82
	(33)	(92)	(0)	(83)	(0)	(100)	(50)	(92)	(17)	(100)	(27)	(92)	(57)
Hospital	12	12	0	12	11	12	6	12	2[a]	12	2	10	103
	(100)	(100)	(0)	(100)	(92)	(100)	(50)	(100)	(18)	100%	(17)	(83)	(72)
Both settings	16	23	0	22	11	24	12	23	4[a]	24	5[a]	21	185
	(67)	(96)	(0)	(92)	(46)	(100)	(50)	(96)	(17)	100%	(22)	(88)	(65)

Abbreviations: DC, direct culture; PC, passage culture.
[a]Sample missing.

TABLE 5 | Distribution of positive cultures by day and healthcare setting, excluding the scissor swab sample.

	Day 0	Day 2	Day 3	Day 4	Day 5	Day 6	Total
	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**
Direct culture							
Primary care	4	0	0	6	1	2	13
	(33)	(0)	(0)	(50)	(8)	(18)	(18)
Hospital	11	0	10	5	1	2	29
	(92)	(0)	(83)	(42)	(9)	(17)	(40)
Both settings	15	0	10	11	2	4	42
	(63)	(0)	(42)	(46)	(9)	(17)	(30)
Passage culture							
Primary care	10	10	12	11	11	10	64
	(83)	(83)	(100)	(92)	(92)	(83)	(89)
Hospital	11	11	11	11	11	9	64
	(92)	(92)	(92)	(92)	(92)	(75)	(89)
Both settings	21	21	23	22	22	19	128
	(88)	(88)	(96)	(92)	(92)	(79)	(89)

TABLE 6 | Distribution of microorganisms by healthcare setting.

Microorganism	Hospital (*N* = 106)		Primary care (*N* = 80)	
	n	%	*n*	%
CoNS	69	65	73	91
S. aureus	29	27	3	4
Neisseria spp.	3	3	1	1
Actinomyces spp.	0	0	2	2.5
Escherichia coli	2	2	0	0
Bacillus spp.	1	1	0	0
Pseudomonas spp.	0	0	1	1
Serratia spp.	1	1	0	0
Streptococcus ssp.	1	1	0	0

Abbreviation: CoNS, coagulase-negative staphylococci.

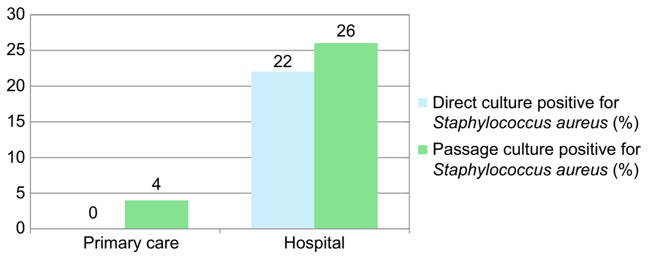

FIGURE 1 | Percentage of culture positive for *Staphylococcus aureus* according to type of healthcare setting.

In addition, microbial diversity was greater in the hospital setting. Gram-negative bacilli such as *Escherichia coli* and *Serratia* spp., as well as *Bacillus* spp., were detected exclusively in hospital samples. In contrast, *Actinomyces* spp. and *Pseudomonas* spp. were identified only sporadically and with lower frequency in primary care samples.

These differences were observed primarily in PC results and should therefore be interpreted as reflecting differences in detectable low-level bioburden under enrichment conditions rather than definitive differences in contamination at the point of clinical use.

3.4 | Differences According to the Type of Dressing (With or Without Silver)

Of the 11 wound dressings included in the study, three contained silver (codes C, E and H) and eight were non-silver dressings. The proportion of positive cultures according to dressing type, healthcare setting and culture method is summarised in Tables 7 and 8.

Overall, high rates of microbial growth were observed in passage cultures (PC) regardless of dressing type or healthcare setting. In the hospital setting, all PC samples obtained from non-silver dressings showed microbial growth after enrichment. Although PC positivity rates were slightly lower for silver-containing dressings, the difference between silver-containing and non-silver dressings was not statistically significant ($p = 0.120$).

When direct cultures (DC) were considered, lower positivity rates were observed compared with PC results for both silver-containing and non-silver dressings. In both healthcare settings, DC positivity increased over time, particularly from Day 4 onwards. Differences between DC and PC positivity were statistically significant across all dressing categories and settings (Table 7).

In silver-containing dressings, microbial growth was detected in 17 of 35 samples (48.6%) in the primary care setting and in 23 of 36 samples (63.9%) in the hospital setting. Although contamination appeared more frequent in hospital samples, this difference did not reach statistical significance ($p = 0.227$).

Analysis by sampling day showed a relatively stable pattern of PC positivity for silver-containing dressings in the hospital setting, with growth detected at nearly all time points. In contrast, DC positivity for silver-containing dressings in primary care was more variable, with no growth detected on Days 2, 3 and 5. Given the limited number of dressing packs and the exploratory nature of the analysis, no formal comparisons by individual dressing type were performed.

Overall, while silver-containing dressings showed a trend toward slightly lower contamination rates, particularly in direct cultures, this effect was inconsistent and insufficient to suggest a protective role against microbial contamination under the routine storage and handling conditions assessed in this study.

3.5 | Contamination of Cutting Scissors

A total of 24 scissor swab samples were collected during the study period, corresponding to the scissors routinely used to cut wound dressings in each healthcare setting. Of these, 18 samples (75.0%) showed microbial growth at some point during the culture process.

Scissor contamination was observed in both healthcare settings. In the primary care setting, 8 of 12 scissor samples (66.7%) were positive, whereas in the hospital setting, 10 of 12 samples (83.3%) showed microbial growth. Although the proportion of positive samples was higher in the hospital setting, this difference was not statistically significant ($p = 0.64$).

Positive scissor cultures were detected from early sampling days and persisted throughout the study period. Both direct cultures (DC) and passage cultures (PC) yielded positive results, with higher detection rates observed after enrichment. This pattern suggests that scissors carried a persistent low-level microbial bioburden under routine clinical use.

The microorganisms identified in scissor samples were similar to those isolated from dressing samples, predominantly coagulase-negative staphylococci, with occasional detection of potentially pathogenic microorganisms. These findings indicate

TABLE 7 | Evolution of microbial contamination according to type of dressing, healthcare setting and collection time.

Presence of silver	Setting	Contamination in DCs (%)	Contamination in PCs (%)	*p*
Silver-containing dressing	Primary care	18%	82%	< 0.001
	Hospital	39%	89%	< 0.001
Non-silver dressings dressing	Primary care	25%	98%	< 0.001
	Hospital	49%	100%	< 0.001

Abbreviations: DC, direct culture; PC, passage culture.

TABLE 8 | Evolution of microbial contamination of silver-containing dressings according to healthcare setting and collection time.

	Day 0		Day 2		Day 3		Day 4		Day 5		Day 6		No. of positive samples	Total no. of samples	% positive
	DC	PC	DC	PC	DC	PC	DC	PC	DC	PC	DC	PC			
Primary care	1	2	0	2	0	3	2	2	0	3	0	2	17	35	49
Hospital	3	3	0	3	3	3	1	3	0	3	0	1	23	36	64

Abbreviations: DC, direct culture; PC, passage culture.

that scissors may act as a shared contact surface and a potential vector for cross-contamination between dressings during routine wound care.

Given that the scissors were not assigned exclusively to the study and were used according to usual clinical practice without a standardised disinfection protocol between uses, the observed contamination reflects typical real-life conditions rather than exceptional circumstances.

4 | Discussion

4.1 | Principal Findings and Overall Interpretation

This study provides empirical evidence that open-but-unused portions of wound dressings may become microbiologically contaminated under routine clinical practice conditions in both primary care and hospital settings. Microbial growth was frequently detectable, particularly after enrichment culture, indicating the presence of low-level bioburden associated with routine storage, handling and environmental exposure.

As all dressings were terminally sterilised and sterile within unopened packs, contamination necessarily occurred after package opening and during subsequent storage and handling.

A key finding of this study is the marked difference between direct culture (DC) and passage culture (PC) results. While approximately one-third of DC samples showed microbial growth exceeding the predefined operational threshold, the vast majority of samples were positive after enrichment. This distinction is important, as enrichment culture increases sensitivity for detecting minimal contamination and does not necessarily reflect the level of contamination present at the point of clinical use. Accordingly, DC results may be considered more representative of contamination immediately detectable at the time of dressing handling, whereas PC results indicate the presence of microorganisms capable of growth under favourable conditions.

Detectable contamination in DC samples was observed from the first sampling day after opening the dressing packs, suggesting that initial exposure and early handling events may play a relevant role in microbial transfer. Over time, DC positivity increased, particularly after several days of storage and repeated handling, supporting the notion of cumulative contamination rather than a single-point event.

These findings are consistent with studies by Berkowitz et al. [7] on adhesive tapes and by Zwanziger and Roper [8] on cut and reused dressings in assisted living facilities, in which bacterial growth was found within the first 24 h of use, with increasing colonisation over time.

These findings should be interpreted within the context of real-life practice. The study was intentionally designed to prioritise ecological validity over experimental control, and no additional aseptic measures beyond routine practice were introduced. As such, the results reflect typical clinical conditions rather than worst-case or optimised scenarios.

4.2 | Microorganisms Identified and Clinical Relevance

The microorganisms most frequently identified in this study were coagulase-negative staphylococci (CoNS), followed by *Staphylococcus aureus*. This distribution is consistent with previous studies assessing contamination of wound care materials and reflects the predominance of skin commensals as the primary source of contamination associated with handling and contact.

CoNS are part of the normal skin microbiota and are commonly isolated in contamination studies [4]. Their high prevalence in both healthcare settings and across sampling days suggests that they may serve as useful indicators of contact-related or handling-related contamination. Although often considered of low pathogenicity, CoNS can act as opportunistic pathogens in vulnerable patients and in the presence of implanted materials or compromised tissue.

The detection of *Staphylococcus aureus*, albeit less frequent than CoNS, is clinically relevant. *S. aureus* is a well-recognised wound pathogen and its presence in open-but-unused dressings indicates that contamination was not limited to harmless commensals. The higher frequency of *S. aureus* observed in the hospital setting may reflect a greater environmental microbial burden or increased exposure to colonised patients and healthcare personnel.

Gram-negative microorganisms and other less frequently isolated species were detected sporadically, mainly after enrichment culture. Their identification suggests that low-level environmental contamination may involve a broader range of microorganisms than those detectable by direct culture alone. However, given their low frequency and the exploratory nature of the study, no conclusions can be drawn regarding systematic differences in contamination patterns by microorganism type.

Importantly, the presence of potentially pathogenic microorganisms does not imply that the use of an open-but-unused dressing would necessarily result in wound infection. Chronic wounds often harbour complex and diverse microbial communities, and the incremental clinical impact of low-level contamination from dressings remains uncertain. Nevertheless, from a patient safety perspective, the introduction of avoidable external microorganisms into the wound environment represents an additional and unnecessary risk, particularly in patients with impaired host defences or delayed wound healing.

4.3 | Differences Between Healthcare Settings

Differences in microbial contamination patterns were observed between the hospital and primary care settings. Overall, a higher proportion of samples from the hospital setting showed microbial growth, particularly in direct cultures and greater microbial diversity was identified compared with primary care.

These findings are consistent with the notion that hospital environments are characterised by higher microbial pressure, greater patient turnover, and more frequent contact with patients colonised or infected with potentially pathogenic microorganisms. In this context, open-but-unused dressings may be more frequently exposed to environmental or contact-related contamination in hospital wards than in outpatient primary care settings. These results are consistent with the findings of the studies by Schifman et al. [11] on blood culture contamination and by LaRocco et al. [12] on urine culture contamination and demonstrate that preventing contamination depends primarily on the measures taken to handle and store clinical material, rather than on the setting in which the material is obtained.

However, it is important to note that differences between settings were more pronounced in direct cultures than in passage cultures, and that enrichment culture yielded high positivity rates in both contexts. This suggests that low-level contamination can occur across different healthcare environments and that the risk is not exclusive to a specific setting.

The higher frequency of *Staphylococcus aureus* detected in hospital samples further supports the influence of environmental and operational factors on contamination patterns. Nevertheless, the study was not designed to isolate the specific determinants of contamination within each setting, such as patient characteristics, staff workload, or environmental cleaning practices.

Taken together, these findings indicate that while the healthcare setting may influence the magnitude and diversity of detectable contamination, the fundamental drivers of microbial transfer, namely repeated handling, shared equipment and storage of partially used materials, are common to both hospital and primary care environments.

4.4 | Silver-Containing Dressings and Storage Conditions

In this study, silver-containing dressings showed slightly lower rates of microbial growth compared with non-silver dressings, consistent with a previous report [6]. However, these differences were small, inconsistent and did not reach statistical significance. Overall, the presence of silver did not prevent microbial contamination under the routine storage and handling conditions assessed.

These findings should be interpreted in light of the known mechanisms of action of silver. The antimicrobial activity of silver ions is dependent on their release in a hydrated environment.

In addition, thioglycollate broth may partially neutralise silver ions once the dressing becomes hydrated, further limiting any residual antimicrobial activity during microbiological processing.

In the present study, dressings were stored in a dry state after opening and before sampling, which likely limited or prevented the activation of silver's antimicrobial properties. As such, the absence of a clear protective effect is biologically plausible and consistent with the physicochemical characteristics of silver-containing dressings.

Environmental factors during storage, such as ambient humidity, may theoretically influence silver activation; however, no specific controls or measurements of humidity were applied, as the study aimed to reflect routine clinical practice. Under these conditions, silver-containing dressings should not be assumed to provide sustained antimicrobial protection against contamination during storage.

Previous studies have suggested that silver-containing dressings may reduce microbial burden when used in contact with moist wounds, but evidence regarding their effectiveness in preventing contamination of unused dressings is limited. Our findings are consistent with this distinction and reinforce the need to differentiate between antimicrobial performance during clinical use and protection against environmental contamination during storage.

Taken together, these results indicate that reliance on silver content alone is not sufficient to mitigate the risk of contamination of open-but-unused dressings. Appropriate handling, storage and single-use practices remain essential to minimise microbial transfer, regardless of the antimicrobial properties of the dressing material.

4.5 | Role of Cutting Scissors as a Potential Vector of Cross-Contamination

One of the most consistent and clinically relevant findings of this study was the high rate of microbial contamination detected on the scissors used to cut wound dressings. Three quarters of scissor samples showed microbial growth, with positive cultures detected in both healthcare settings and across multiple sampling days.

Unlike dressings, which are exposed intermittently, scissors are repeatedly handled, shared between procedures and come into direct contact with different materials and surfaces. Under routine clinical practice, scissors are often perceived as "clean" instruments rather than as critical points in the chain of aseptic handling. The findings of this study challenge this assumption and suggest that scissors may act as fomites, serving as passive reservoirs and vectors for cross-contamination.

The similarity between microorganisms isolated from scissor samples and those detected on dressings supports the hypothesis that scissors may contribute to cross-contamination during the cutting process. This is particularly relevant given that the scissors used in this study were not assigned exclusively to the research protocol and were subject only to usual local disinfection practices, reflecting typical real-life conditions.

From a patient safety perspective, the identification of contaminated scissors highlights an often-overlooked risk factor in wound care practice. Even when dressings are handled with appropriate hand hygiene, the use of contaminated cutting instruments may undermine aseptic efforts and facilitate the transfer of microorganisms to unused dressing material.

These findings underscore the importance of considering cutting instruments as a critical control point in wound care protocols. The use of disposable scissors, strict disinfection procedures between uses, or alternative dressing formats that eliminate the need for cutting may represent effective strategies to reduce the risk of indirect contamination.

4.6 | Study Limitations

This study has several limitations that should be acknowledged. First, the observational and descriptive design does not allow causal inferences to be made regarding the relationship between the use of open-but-unused dressings and clinical infection outcomes. Although microbial contamination was frequently detected, the direct clinical impact of this contamination was not assessed.

Second, the study was conducted in a single hospital unit and one primary care centre, which may limit the generalizability of the findings to other healthcare settings with different organisational structures, workloads, or infection prevention practices.

Third, only one dressing pack per dressing type and healthcare setting was included, resulting in repeated measurements from the same packs over time. While this approach allowed exploration of temporal patterns under real-life conditions, it limited the ability to perform inferential statistical analyses that account for intra-pack correlation.

Fourth, storage and handling conditions were not standardised and environmental variables such as temperature and humidity were not measured. However, this was an intentional methodological choice to reflect routine clinical practice and enhance ecological validity.

Fifth, microbiological analysis relied on aerobic culture and liquid enrichment, which may have favoured the growth of faster-growing microorganisms and underestimated the presence of anaerobic or slow-growing species. Finally, no study-specific negative controls were implemented beyond standard laboratory quality control procedures.

4.7 | Implications for Clinical Practice

Despite these limitations, the findings of this study have relevant implications for clinical practice, patient safety and the quality of wound care. The frequent detection of microbial contamination in open-but-unused dressings, even at early time points after opening, suggests that reuse of partially used dressings may represent an avoidable source of microbial transfer in wound care and may pose a potentially avoidable risk.

From a clinical perspective, the results support existing manufacturer recommendations advocating for single-use, sterile dressings. Where reuse is unavoidable due to organisational constraints, strict attention to handling, storage and aseptic technique is essential. Although this study did not directly assess the clinical impact, the presence of pathogenic microorganisms such as *Staphylococcus aureus* or Pseudomonas spp. should be considered a sufficient risk indicator to justify the need to critically review standard practices related to the use of open-but-unused dressings.

This evidence has important implications for nursing activities. Storage and use of open-but-unused wound dressings should be discouraged, except in strictly controlled cases, prioritising the use of single-use, sterile dressings of a size appropriate to the wound. Customising the formats available in product catalogues to each healthcare unit is a key practical organisational measure that could be used to reduce the need for cutting and minimise the associated risks.

Furthermore, the high contamination rate observed on cutting scissors highlights a critical and often overlooked point in wound care practice. Implementing standardised disinfection protocols, using disposable cutting instruments, or adopting dressing formats that do not require cutting may reduce the risk of indirect contamination.

In addition, optimising product catalogues to include a broader range of dressing sizes and formats may help minimise the need for cutting and reuse, thereby enhancing patient safety without compromising resource efficiency.

The differences found between settings and types of dressing reinforce the need for ongoing training on medical device handling practices and biosafety principles in wound care.

The appropriate use of opened but unused materials should be integrated into good clinical practice guidelines and patient safety plans in healthcare units, as part of nurses' commitment to preventing adverse events and improving quality.

5 | Conclusions

The results of this study show a high rate of microbial contamination in open-but-unused dressings, present from the first few days after opening.

Under routine clinical practice conditions, open-but-unused portions of wound dressings were frequently found to harbour detectable microbial contamination, particularly after enrichment culture. Contamination was observed across dressing types and healthcare settings and was detectable from the early stages after opening.

While silver-containing dressings showed slightly lower contamination rates, the presence of silver did not prevent microbial growth under the dry storage conditions assessed. Cutting scissors emerged as a consistent potential vector for cross-contamination.

These findings do not demonstrate a direct link between dressing contamination and wound infection; however, they highlight an avoidable breach in aseptic practice that warrants attention. Revising wound care protocols to discourage reuse of open-but-unused dressings and to address the role of shared cutting instruments may contribute to safer, more evidence-based wound care.

Healthcare institutions should review their protocols for the management of leftover supplies according to their availability, and increase the range of products of different sizes stocked, to minimise the use of leftover samples and enhance patient safety.

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Disclosure

The authors have checked to make sure that our submission conforms as applicable to the Journal's statistical guidelines. The authors affirm that the methods used in the data analyses are suitably applied to their data within their study design and context, and the statistical findings have been implemented and interpreted correctly. The authors agree to take responsibility for ensuring that the choice of statistical approach is appropriate and is conducted and interpreted correctly as a condition to submit to the Journal.

Ethics Statement

The research was approved by the relevant research ethics committee (Comité de Ética de la Investigación de Cádiz, project code SICEIA-2024-000277).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** STROBE statement—checklist of items that should be included in reports of cross-sectional studies. **Data S2:** STROBE checklist—longitudinal observational study.