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ORIGINAL RESEARCH **OPEN ACCESS**

Microbial contamination of two non-sterile latex examination glove brands marketed in Trujillo, Peru: a laboratory study

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ABSTRACT

Background: Non-sterile latex examination gloves are routinely used as barrier protection in dental practice; however, microbial contamination may be present before clinical use and potentially compromise infection-control procedures. **Objective:** To compare the microbial contamination of two brands of non-sterile latex examination gloves marketed in Trujillo, Peru. **Methods:** A comparative laboratory study was conducted using 132 unused latex examination gloves, including 66 Endoglove and 66 BeeSure specimens. Gloves were aseptically removed from their original boxes and processed individually using a microbiological rinse procedure followed by incubation and culture. Microbial growth was quantified as colony-forming units (CFU), and recovered microorganisms were classified according to the laboratory identification. **Results:** Endoglove specimens yielded 95 CFU and BeeSure specimens 80 CFU. Overall, Klebsiella was the most frequently recovered bacterium (47 CFU; 26.86%), followed by Salmonella (38 CFU; 21.71%), enterococci (25 CFU; 14.29%), Staphylococcus epidermidis (21 CFU; 12.00%), yeasts (17 CFU; 9.71%), Staphylococcus aureus (14 CFU; 8.00%), and Staphylococcus saprophyticus (13 CFU; 7.43%). **Conclusions:** Microbial contamination was detected in unused non-sterile latex examination gloves from both brands, with a higher total CFU count in Endoglove than in BeeSure. Bacterial species predominated among the recovered microorganisms, particularly Klebsiella and Salmonella.

Keywords: Gloves, Protective; Equipment Contamination; Cross Infection; Bacteria; Dentistry.

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Introduction

Infection prevention and control is a fundamental component of safe dental care because dental professionals are routinely exposed to saliva, blood, mucous membranes, contaminated instruments, and aerosols that may contain transmissible microorganisms. Standard precautions are therefore required for every patient regardless of known infection status and include hand hygiene, appropriate personal protective equipment, environmental disinfection, and correct processing of reusable instruments [1]. Gloves constitute one of the principal protective barriers during dental procedures and are intended to reduce direct contact between the hands of dental personnel and potentially infectious biological material [1,2].

Non-sterile examination gloves are appropriate for routine nonsurgical healthcare procedures in which contact with blood, body fluids, mucous membranes, or contaminated surfaces may occur, whereas sterile gloves are required when maintenance of a sterile field is necessary. Nevertheless, gloves do not replace hand hygiene and do not constitute an absolute microbiological barrier. Current recommendations emphasize hand hygiene before donning and after removing gloves, single-patient use, proper removal technique, and avoidance of washing or reusing disposable examination gloves [3]. Their microbiological condition before use is therefore relevant because contamination present on an unused glove could theoretically contribute to microorganism transfer during handling or patient care.

Evidence indicates that non-sterile gloves obtained directly from dispensing boxes may harbor viable microorganisms. Paul et al. found measurable bacterial contamination on non-sterile gloves collected in healthcare environments and reported microbial loads comparable with those detected on healthcare workers' hands after hand hygiene [4]. More recently, Cabeau et al. identified viable microorganisms on unused non-sterile gloves, including specimens obtained from previously unopened packaging, demonstrating that microbial recovery is not necessarily restricted to gloves contaminated after patient contact [5]. These findings indicate that the term “non-sterile” has practical microbiological implications and that contamination may originate from manufacturing, packaging, storage, dispensing, or subsequent handling conditions.

Earlier microbiological investigations provide additional evidence that unused examination gloves can contain both environmental and potentially clinically relevant organisms. Hughes et al. recovered bacteria from unused non-sterile gloves and identified organisms including Enterococcus faecalis, Klebsiella pneumoniae, Staphylococcus aureus, and coagulase-negative staphylococci [6]. Contemporary research has continued to emphasize the role of glove-box handling as a possible contamination pathway; Rose et al. demonstrated that the design and manipulation of glove dispensers influence contamination of box surfaces, reinforcing the importance of retrieval practices and storage conditions [7]. Nevertheless, available studies have predominantly been conducted in hospital or general healthcare environments rather than specifically evaluating commercially available examination gloves used in dental settings.

The microbiological quality of unused examination gloves may be particularly relevant in dentistry because gloves are frequently in direct contact with oral mucosa and are repeatedly retrieved from multi-unit dispensing boxes throughout the clinical day. Although non-sterile gloves are not expected to meet sterility standards, differences in microbial burden among commercially available products could provide useful information regarding their pre-use microbiological condition. Evidence comparing individual brands remains limited, and data from commercially available latex examination gloves in Peruvian dental settings are particularly scarce.

Therefore, evaluating unused gloves before clinical contact may provide evidence on microbial contamination that is independent of contamination acquired during dental treatment. Such information may contribute to a better understanding of glove handling, storage, and infection-control practices without implying that non-sterile examination gloves should be sterile or routinely subjected to sterilization. Accordingly, the objective of this study was to compare the microbial contamination of Endoglove and BeeSure non-sterile latex examination gloves marketed in Trujillo, Peru.

Materials and methods

Study design and setting

A quantitative, comparative, cross-sectional laboratory study was conducted to evaluate microbial contamination in unused non-sterile latex examination gloves from two commercially available brands. The microbiological procedures were performed during 2021 at the Microbiology Laboratory of the Faculty of Biological Sciences, Universidad Nacional de Trujillo,

Trujillo, Peru, after obtaining institutional authorization for use of the laboratory facilities. The manuscript was structured according to the principles of the Checklist for Reporting In-vitro Studies (CRIS) [8].

Population, sample size, and sampling

The study population comprised 200 unused non-sterile latex examination gloves from the Endoglove and BeeSure brands. Sample size was estimated using the finite-population formula reported in the original study, considering a population of 200 gloves, a 95% confidence level (Z = 1.96), and a precision of 5%, resulting in a required sample of 132 gloves. The final sample consisted of 66 Endoglove and 66 BeeSure gloves.

At the product level, sampling was non-probabilistic by convenience according to brand availability and the predefined eligibility criteria. After the two boxes had been obtained, 66 gloves were randomly selected from each box for microbiological examination. Thus, both brands contributed an equal number of experimental units.

Eligibility criteria

Unused non-sterile latex examination gloves from the Endoglove or BeeSure brands were eligible when they were obtained from appropriately sealed commercial packaging and showed no visible deterioration. Gloves from other brands and specimens showing perforations, visible contamination, or other evident physical defects were excluded. Boxes with damaged or inadequately sealed packaging were also excluded.

Study variables

The primary variable was microbial contamination, operationalized as microbial growth recovered from each glove and ultimately recorded as colony-forming units (CFU). Glove brand was the principal comparison variable and comprised two categories: Endoglove and BeeSure.

The secondary microbiological variable was the type of microorganism recovered. The laboratory records classified isolates into the following groups: Enterococcus spp., Klebsiella spp., yeasts, Salmonella spp., Staphylococcus saprophyticus, Staphylococcus aureus, and Staphylococcus epidermidis. The term microbial contamination was used for the overall outcome because the recovered microorganisms included both bacteria and yeasts.

Microbiological data collection

Microbial contamination was assessed through laboratory microbiological observation. A structured microbiological data collection sheet was used to record glove brand, recovered microbial growth, CFU counts, and the microorganism type assigned during laboratory identification.

No Vernier caliper was considered a microbiological measurement instrument in the present manuscript because CFU are obtained from culture-based microbiological assessment rather than dimensional measurement. Similarly, psychometric validity or reliability coefficients were not applicable. Quality control instead relied on standardized aseptic handling, sterile instruments, controlled incubation conditions, and microbiological processing performed in the laboratory with participation of a microbiology specialist.

Microbiological procedure

One commercially packaged box of each glove brand was acquired and transported under ambient conditions to the Microbiology Laboratory. Before sample manipulation, laboratory biosafety measures were implemented, including protective clothing, face masks, hand hygiene, and sterilization of the forceps used for specimen handling. The procedures were conducted by the researcher with the participation of a microbiology specialist.

Sixty-six gloves from each box were randomly selected using sterile forceps and placed individually into separate containers. Each glove was then subjected to an immersion-rinse procedure in peptone broth. The specimen was completely submerged so that both external and internal surfaces came into contact with the broth. After immersion, the glove was removed with sterile forceps, and the corresponding broth was transferred to a closed container for microbiological incubation.

The initial cultures were incubated at 37 °C for 24 hours. After incubation, microbial growth was preliminarily evaluated through changes in broth turbidity. Subsequently, a 10-mL aliquot of the peptone broth was processed with distilled water and BRILA broth according to the laboratory protocol documented in the study and incubated for an additional 48 hours at 37 °C.

Gas production and microbiological growth were then evaluated as part of the laboratory workflow.

Final microbiological findings were registered by the laboratory as CFU and according to the microorganism groups identified.

Statistical Analysis

The original study database was processed using Microsoft Excel 2007 and IBM SPSS Statistics, version 16.0. For the present manuscript, microbial findings were summarized using absolute CFU counts and relative frequencies according to glove brand and microorganism type. Total microbial recovery was calculated separately for Endoglove and BeeSure gloves and for the overall sample. Percentages for microorganism distribution were calculated using the total CFU recovered within the corresponding denominator.

Ethical considerations

The study evaluated commercially available unused examination gloves and did not involve human participants, identifiable personal information, human biological specimens, or experimental animals. Therefore, informed consent and the Declaration of Helsinki were not applicable. Institutional authorization was obtained to conduct the microbiological procedures at the Microbiology Laboratory of the Universidad Nacional de Trujillo. The research was conducted according to applicable institutional principles of scientific integrity and laboratory biosafety.

Results

A total of 132 unused non-sterile latex examination gloves were analyzed, including 66 Endoglove and 66 BeeSure specimens. Microbial growth was recovered from the evaluated samples, with a total of 175 colony-forming units (CFU) recorded across both brands. Endoglove specimens accounted for 95 CFU (54.29% of the total recovered microbial load), whereas BeeSure specimens accounted for 80 CFU (45.71%) (Table 1).

Seven microorganism types were recorded in the laboratory findings. Klebsiella spp. represented the largest proportion of the total microbial recovery, with 47 CFU (26.86%), followed by Salmonella spp. with 38 CFU (21.71%) and enterococci with 25 CFU (14.29%). Staphylococcus epidermidis accounted for 21 CFU (12.00%), yeasts for 17 CFU (9.71%), Staphylococcus aureus for 14 CFU (8.00%), and Staphylococcus saprophyticus for 13 CFU (7.43%) (Table 2).

Within Endoglove specimens, the largest microbial counts corresponded to Klebsiella spp. (26 CFU; 27.37%) and Salmonella spp. (20 CFU; 21.05%). In BeeSure specimens, these microorganisms were also the most frequently recovered, accounting for 21 CFU (26.25%) and 18 CFU (22.50%), respectively. The remaining microorganism types showed lower counts in both brands (Table 2).

Discussion

The main finding of this study was the recovery of microbial contamination from unused non-sterile latex examination gloves of both commercial brands evaluated. Endoglove specimens yielded a higher total microbial count than BeeSure specimens, with 95 and 80 CFU, respectively. Across both brands, Klebsiella spp. represented the largest proportion of the recovered microorganisms, followed by Salmonella spp. and enterococci. Yeasts were also recovered, confirming that contamination was not exclusively bacterial. Because the original individual-level dataset was unavailable, the difference between brands should be interpreted descriptively rather than as evidence of a statistically significant difference.

The finding of microorganisms on unused non-sterile latex gloves is consistent with previous evidence showing that gloves obtained from dispensing boxes may harbor viable microorganisms before patient contact. Alqumber evaluated unused non-sterile latex disposable gloves and documented contamination with both skin commensals and healthcare-associated bacterial pathogens. Importantly, bacterial counts decreased after implementation of hand-hygiene reminder signs, suggesting that contamination of gloves within dispensing environments may be influenced by handling practices [9]. The present findings are consistent with the general observation that an unused glove should not automatically be considered microbiologically free of contamination simply because it has not yet been worn.

Evidence from dental settings is particularly relevant. Helmi et al. evaluated unused non-sterile latex gloves in university dental clinics and found microbial contamination in gloves retrieved from opened boxes. They additionally observed differences according to the proximity of glove boxes to dental chairs, suggesting that the clinical environment and positioning of dispensers

Table 1. Overall microbial load recovered from unused non-sterile latex examination gloves according to brand

Glove brand	Gloves analyzed, n	Recovered microbial load, CFU	% of total CFU
Endoglove	66	95	54.29
BeeSure	66	80	45.71
Total	132	175	100.00

Note: CFU, colony-forming units. Percentages were calculated using the total microbial recovery of 175 CFU as the denominator.

Table 2. Distribution of microorganisms recovered from Endoglove and BeeSure non-sterile latex examination gloves

Microorganism type	Endoglove, CFU	Endoglove, %	BeeSure, CFU	BeeSure, %	Total CFU	Total %
Enterococci	14	14.74	11	13.75	25	14.29
Klebsiella spp.	26	27.37	21	26.25	47	26.86
Yeasts	10	10.53	7	8.75	17	9.71
Salmonella spp.	20	21.05	18	22.50	38	21.71
Staphylococcus saprophyticus	8	8.42	5	6.25	13	7.43
Staphylococcus aureus	7	7.37	7	8.75	14	8.00
Staphylococcus epidermidis	10	10.53	11	13.75	21	12.00
Total	95	100.00	80	100.00	175	100.00

Note: CFU, colony-forming units. Percentages for each brand were calculated using 95 CFU for Endoglove and 80 CFU for BeeSure as the respective denominators; overall percentages used 175 CFU as the denominator.

may influence microbial exposure [10]. This finding provides an important context for the present study because dental clinics generate aerosols and droplets and involve repeated handling of glove boxes. However, the present investigation evaluated commercially acquired gloves rather than serial contamination within functioning dental operatories; consequently, the mechanisms of contamination cannot be considered equivalent between studies.

The microorganism profile observed also warrants consideration. Earlier evidence on unused non-sterile gloves identified organisms such as Klebsiella pneumoniae, Enterococcus faecalis, Staphylococcus aureus, and coagulase-negative staphylococci [6]. Similarly, more recent investigations have demonstrated that unused non-sterile gloves may contain viable microorganisms even before clinical use [4,5]. The recovery in the present study of Klebsiella spp., enterococci, S. aureus, S. epidermidis, and S. saprophyticus is therefore biologically compatible with previous glove-contamination research. Nevertheless, because the thesis did not document the selective media, biochemical identification panels, molecular methods, or confirmatory procedures used for every taxonomic assignment, the specific microbial identifications reported here should be interpreted according to the original laboratory records rather than as molecularly confirmed isolates.

The recovery of yeasts in both glove brands further supports the use of the broader term microbial contamination for the primary outcome. In the present study, yeasts accounted for 17 of the 175 recovered CFU (9.71%). Because no genus or species identification was documented, their clinical relevance cannot be determined and they should not be assumed to represent a particular fungal pathogen. This distinction is important because microbial contamination encompasses bacteria and fungi, whereas referring exclusively to bacterial contamination would omit part of the original experimental findings.

Hand hygiene remains central when interpreting contamination of examination gloves. An updated systematic review by Price et al. concluded that established hand-hygiene techniques reduce microbial load on healthcare workers' hands, although considerable methodological heterogeneity exists among studies [11]. Similarly, the SHEA/IDSA/APIC practice recommendations emphasize that non-sterile glove use must be integrated with appropriate hand hygiene because gloves may become contaminated and hands can also become contaminated during glove removal [12]. Therefore, the presence of microorganisms on unused gloves should not be interpreted as evidence that gloves are ineffective, but rather as confirmation that glove use represents only one component of a broader infection-prevention strategy.

Differences between the two brands should also be interpreted cautiously. The 15-CFU difference observed between Endoglove and BeeSure may reflect characteristics related to the tested products, but the study did not evaluate manufacturing processes, latex composition, production hygiene, packaging technology, storage duration, transport conditions, or individual batch characteristics. Recent experimental research by Machado et al. showed measurable differences in the physical integrity of unused latex procedure gloves from different brands, including pre-use defects in some products [13]. Such evidence demonstrates that commercially available glove brands are not mechanically identical; however, it does not establish that material characteristics caused the microbial-count difference found in the present investigation.

Handling practices after a glove box is opened may provide another plausible pathway for contamination. Kristiansen et al. observed frequent deviations from recommended glove-use practices among healthcare workers, including overuse and absence of hand hygiene after glove removal [14]. Although their study evaluated clinical behavior rather than microbial contamination of unopened products, it highlights the multiple opportunities through which dispensing boxes and subsequently withdrawn gloves can become contaminated during routine healthcare activities. The present study cannot determine whether the recovered microorganisms originated before packaging, during distribution or storage, or during specimen retrieval, and therefore no specific contamination source should be assigned.

The potential relevance of contaminated gloves lies in their capacity to participate in microbial transfer when infection-control practices are inadequate. Adediran et al. demonstrated that contamination of healthcare personnel gloves and gowns with methicillin-resistant S. aureus occurred after routine patient-care interactions and that transfer to a subsequent simulated patient was possible in the absence of appropriate precautions [15]. Their study concerned contamination acquired during patient care, whereas the present investigation addressed unused gloves; nevertheless, it demonstrates that microorganisms present on glove surfaces can have relevance to cross-transmission pathways.

The dynamic nature of glove contamination has also been demonstrated during procedures performed under controlled conditions. Lee et al. found no bacterial contamination immediately after sterile surgical gloves were donned or after surgical draping, but detected contamination later during clean orthopedic procedures [16]. Although sterile surgical gloves differ fundamentally from non-sterile examination gloves, these findings reinforce an important principle: the microbial status of a glove changes according to exposure and handling conditions. Therefore, the CFU recovered in the present study represent the microbiological condition of the evaluated specimens at the time of laboratory processing and should not be extrapolated to contamination levels during or after dental treatment.

Glove-box design itself may also influence opportunities for contamination. Rose et al. recently showed that a modified glove box produced significantly less internal and overall surface contamination than a conventional box design [17]. This supports the concept that infection prevention should consider not only glove composition but also packaging, dispenser configuration, placement, and withdrawal technique. Such factors were not experimentally compared in the present investigation, but they provide plausible targets for future studies designed to determine why contamination levels may differ among commercially available glove products.

The importance of appropriate glove management is further supported by contemporary clinical evidence. In a multicenter cohort study, O'Hara et al. reported MRSA contamination of healthcare personnel gloves in 15.4% of observed interactions involving patients with recent MRSA-positive cultures, with higher contamination when direct patient contact occurred [18]. These data should not be directly compared numerically with the CFU observed in unused examination gloves, but they illustrate that glove surfaces can become relevant reservoirs of microorganisms during healthcare activity

and that contamination risk depends strongly on the context of use.

From a dental perspective, the detection of microorganisms on non-sterile examination gloves does not imply that such gloves are inappropriate for all clinical procedures. A 2026 systematic review and meta-analysis comparing sterile and non-sterile gloves for dental extractions found very low postoperative infection rates and did not demonstrate a statistically significant reduction in socket infection with sterile gloves, although the authors highlighted limitations in the available evidence [19]. Therefore, the present findings should not be interpreted as support for replacing non-sterile examination gloves with sterile gloves during every dental procedure. Rather, glove selection should remain appropriate to the invasiveness and aseptic requirements of the procedure.

More broadly, Kramer et al. emphasized that single-use medical gloves perform their protective function appropriately only when used according to their indications and in conjunction with hand hygiene [20]. Their review also notes that microbial contamination of non-sterile gloves may vary with the duration for which a glove box has been open and the extent of manipulation to which it has been subjected. Consequently, the practical implication of the present findings is not to disinfect, wash, sterilize, or reuse examination gloves—practices that could compromise their integrity—but to reinforce correct storage, clean dispensing conditions, hand hygiene before glove placement when indicated, avoidance of unnecessary contact with gloves remaining in the box, and replacement of gloves between patients and procedures.

Among the strengths of this study were the direct microbiological evaluation of unused gloves before clinical use, equal allocation of specimens between both commercial brands, examination of 132 individual gloves, aseptic retrieval with sterile forceps, and laboratory processing under controlled incubation conditions. In addition, reporting the complete distribution of the recovered microorganisms rather than only the total CFU provides a more informative description of the microbiological profile. The study also addresses a locally relevant issue for dental infection control for which evidence from Peruvian commercial products remains limited.

Several limitations should be acknowledged. Most importantly, only one box of each brand was sampled; therefore, the findings may reflect the particular boxes or batches evaluated and cannot establish consistent brand-level microbiological superiority. Second, the original individual glove-level database was no longer available, preventing reproducible inferential comparison between brands and calculation of confidence intervals around individual contamination measures. Third, the laboratory records did not provide sufficient detail regarding selective culture media, biochemical tests, molecular confirmation, or the complete workflow used to identify each microorganism. Fourth, the study combined descriptions of the most-probable-number procedure with CFU reporting, preventing reconstruction of the exact quantitative microbiological pathway from the archived documentation. Fifth, no sterile-glove comparator or microbiological negative-control results were documented. Finally, storage conditions, manufacturing lot, duration since manufacture, time since box opening, and possible environmental sources of contamination were not systematically measured. These limitations require the findings to be interpreted as a descriptive comparison of the tested specimens, rather than definitive evidence that one commercial brand is microbiologically safer than the other.

Future investigations should evaluate multiple boxes and manufacturing lots from each brand, preferably purchased from different distributors and sampled at predefined stages from initial box opening onward. Individual CFU counts per glove should be retained to permit estimation of means or medians, dispersion measures, confidence intervals, and appropriately selected inferential comparisons. Standardized culture methods should include documented negative and positive controls, selective and differential media, and confirmatory identification through validated biochemical platforms, MALDI-TOF mass spectrometry, or molecular methods when available. Future studies should also compare packaging configuration, box-opening duration, storage conditions, retrieval technique, and location within dental operatories to determine which factors contribute most strongly to pre-use microbial contamination.

Conclusions

Microbial contamination was detected in unused non-sterile latex examination gloves from both brands evaluated. Endoglove specimens showed a higher total microbial recovery than BeeSure specimens, with 95 and 80 CFU, respectively. Klebsiella spp. and Salmonella spp. were the most frequently recovered bacteria in both brands, while enterococci, Staphylococcus species, and

yeasts were also identified. These findings indicate that unused non-sterile latex examination gloves may contain viable microorganisms before clinical use and reinforce the importance of appropriate storage, dispensing, hand hygiene, and handling practices as part of infection-control procedures.

Author Contributions Statement (CrediT)

MAG: Conceptualization, Methodology, Investigation, Data Curation, Writing – Original Draft, and Project Administration, Revision and Editing.

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Conflict of Interest

The author reports no financial relationships, commercial interests, institutional commitments, or personal circumstances that could have inappropriately influenced this research.

Data Availability

The dataset is available upon request. The aggregated data supporting the findings of this study are presented in full in the manuscript and its accompanying tables.

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