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KNOWLEDGE, ATTITUDES, AND PRACTICES RELATED TO CROSS-INFECTION CONTROL IN DENTAL LABORATORIES

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AMR	Antimicrobial Resistance
BADT	Bulgarian Association of Dental Technicians
BgDA	Bulgarian Dental Association
HAIs	Healthcare-Associated Infections
IPC	Infection Prevention and Control
PPE	Personal Protective Equipment
CoM	Council of Ministers
MTL	Medical-Technical Laboratory
WHO	World Health Organization
IMTL	Independent Medical-Technical Laboratory
OHS	Occupational Health Service
HIV	Human Immunodeficiency Virus
ADA	American Dental Association
BDA	British Dental Association
CDC	Centers for Disease Control and Prevention
ECDC	European Centre for Disease Prevention and Control
FDI	World Dental Federation
HBV	Hepatitis B Virus
HCV	Hepatitis C Virus

INTRODUCTION

Infection prevention and control (IPC) are pivotal to patient safety and the quality of care, representing a universal mandate for healthcare professionals and patients alike, as well as a critical component of every clinical interaction. According to the World Health Organization (WHO) *Global Strategy on Infection Prevention and Control*, healthcare-associated infections (HAIs) remain among the most prevalent adverse events encountered during healthcare delivery. Active IPC programmes have been shown to be the most effective approach to safeguarding patients, healthcare practitioners, and visitors to healthcare facilities by mitigating the risk of infections acquired during the provision of care.

Infection prevention and control aims not only to limit the transmission of diseases within healthcare settings but also to foster a culture of safety through enhanced awareness, professional accountability, and the implementation of sustainable practices. This is of particular importance in environments marked by a heightened risk of exposure to potentially infectious agents, such as dental healthcare facilities.

One of the most significant drivers of strengthened infection control in dental offices is the risk of transmission of blood-borne pathogens, including hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV). These infections constitute well-recognised occupational hazards for dental professionals, with dental laboratory practice being not exempt from them.

The global COVID-19 pandemic has further underscored the critical importance of infection control in dental environments, resulting in more stringent regulatory requirements that have significantly influenced clinical organisation and quality assurance protocols. The crisis highlighted the necessity for continuous professional development, improved resource management, and the rapid integration of innovative technologies to safeguard both patients and healthcare personnel.

Over time, infection prevention and control have evolved into highly regulated and indispensable components of oral healthcare, carrying equal significance for all stakeholders, including dental professionals, patients, and the broader community.

The risk of cross-infection in dental practice, as well as the transmission of infectious agents from dental offices to dental laboratories, is well documented. Reports of infections associated with dental treatment include instances of patient-to-patient transmission. To mitigate such risks, governmental authorities and professional dental organisations have established and implemented regulations, protocols, and evidence-based recommendations to standardize IPC practices within dental healthcare facilities.

While specific guidelines exist for the containment of infectious microorganisms within dental laboratories, infection control in these settings remains a frequently overlooked dimension of dental technology practice. As an integral link in the dental care chain, laboratories are required to implement comprehensive safety protocols and rigorous decontamination policies. To this end, the FDI World Dental Federation emphasizes the necessity of continuous monitoring of infection control practices and on-going professional education to maintain high standards of clinical safety.

Despite substantial progress in the development of infection control guidelines and protocols over the years, significant challenges remain in ensuring their consistent implementation across all healthcare settings, including dental laboratories. Effective cross-infection prevention is essential for safeguarding both patients and dental personnel. Against this backdrop, the knowledge, attitudes, and practices (KAP) of dental professionals regarding infection control in dental laboratories are decisive for promoting best practices and maintaining a safe environment for both patients and the dental team.

[1] The references cited in this extended abstract are retained by the author and may be provided upon request.

AIM, OBJECTIVES, MATERIALS, AND METHODS

1. Aim of the study

The present study aims to investigate the knowledge, attitudes, and practices (KAP) of dental professionals regarding cross-infection control in dental laboratories in Bulgaria.

To achieve this aim, the following objectives have been formulated:

2. Objectives:

1. To provide a historical review and analysis of international IPC policies and guidelines within the field of dental practice, with a particular focus on the evolution of standards relevant to dental laboratories;
2. To review and analyse the regulatory framework governing infection prevention and control in dental laboratories in Bulgaria;
3. To examine the scope and methodological approaches of international research on cross-infection control in dental laboratories;
4. To conduct a nationally representative survey assessing the knowledge, attitudes, and practices (KAP) of dental technicians in Bulgaria regarding infection control;
5. To evaluate disinfection process and the communication between dental offices and dental laboratories as key factors influencing infection control within the dental laboratory setting.

3. Research hypotheses

1. In contrast to international standards, there is a conspicuous lack of specific IPC guidelines in Bulgaria explicitly addressing dental laboratories.
2. Significant knowledge gaps exist among Bulgarian dental technicians regarding cross-infection control.
3. Dental technicians in Bulgaria perceive the risk of occupationally acquired infections as low, which influences their attitudes towards the issue;
4. Certain aspects of infection control practices in dental laboratories are suboptimal and do not fully align with internationally accepted guidelines;

5. The level of communication between dental offices and dental laboratories concerning infection control is insufficient to ensure procedural safety;

6. There is a demonstrable need for structured professional educational interventions to improve awareness and infection control practices in this field.

4. Materials and methods

In order to address the stated primary aim and specific objectives of this research, the following study components were designed and executed:

- A descriptive review of international research examining the knowledge, attitudes, and practices (KAP) of dental technicians globally concerning infection control in their professional practice;
- An analytical review of international and national policies and guidelines for best practice, issued by health and professional dental organisations, pertaining to infection prevention and control;
- A descriptive cross-sectional study assessing the knowledge, attitudes, and practices (KAP) regarding infection control among dental technicians in Bulgaria;
- A descriptive cross-sectional study evaluating disinfection practices in dental healthcare facilities and the clinical-laboratory communication regarding infection control.

4.1. Historical review of the evolution of international and national policies and guidelines for good practice issued by international and national health and professional organisations

A structured search was undertaken to identify published regulatory documents, clinical guidelines, and professional recommendations pertaining to infection prevention and control (IPC) in dentistry, including in the dental laboratory setting. The review encompassed standards of good professional practice issued by international and national health authorities and professional dental organisations. The search was executed in both English and Bulgarian, querying electronic databases, such as: PubMed, Embase, Scopus, ScienceDirect, Wiley Online Library, and ResearchGate. The inclusion period spanned from 1970 to 2025. The search strategy employed

the following keywords: *infection control, dentistry, dental laboratory, guidelines, recommendations,* and *policies*.

Furthermore, targeted grey literature searches were performed on the official portals of the following organizations: FDI World Dental Federation (FDI), Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), European Centre for Disease Prevention and Control (ECDC), American Dental Association (ADA), the Ministry of Health of the Republic of Bulgaria, the Bulgarian Association of Dental Technicians (BADT), and the Bulgarian Dental Association (BgDA).

To address the Bulgarian infection control regulatory documents, public health specialists from the Regional Health Inspectorate (RHI) of Varna and lecturers from the "Public Health Inspector" programme at the Medical College of Varna were consulted as experts.

Retrieved publications and documents were assessed for eligibility against predefined inclusion criteria. To be included in the review, documents were required to: have been issued by international health and national professional organisations; have influenced the formulation and evolution of infection control guidelines in dental settings globally, with particular reference to the United States, European countries, and Bulgaria, between 1970 and 2025; and be available in full-text format in either English or Bulgarian.

Data were systematically extracted from all eligible documents, including: authorship, year of publication, title, the presence of dedicated sections addressing infection control in dental laboratories, and the thematic content of those sections.

4.2. Descriptive review of global studies on dental technicians' knowledge, attitudes, and practices regarding infection control in professional practice

A search was conducted across electronic databases, including PubMed, Embase, Scopus, ScienceDirect, Wiley Online Library, and ResearchGate, for scientific articles published in English between January 2000 and May 2023. The search was further expanded through a manual review of the reference lists of all articles identified as eligible for inclusion. The search strategy employed the following keywords: *dental laboratory, cross-infection control, dental technicians, knowledge, attitudes, practice*.

Inclusion criteria: To be included in the review, studies were required to: report original research data on the knowledge, attitudes, and practices of dental technicians regarding infection prevention and control in dental laboratories; be published in peer-reviewed journals; and be available in full-text format in English.

Exclusion criteria: studies were excluded from the review if they: described infection control protocols in dental laboratories without presenting empirical data; were experimental investigations focused solely on sources of contamination in laboratories; or involved student populations rather than professional dental technicians.

Data were systematically extracted from each publication, including: authorship, year of publication, study period, title, study design, level of data collection (individual or group), sample size, and respondent demographics (length of professional experience, age, sex, position, and workplace). In addition, details of the research instrument were recorded, including the methods used to assess knowledge, attitudes, and practices.

4.3. Study on the knowledge, attitudes, and practices (KAP) of dental technicians regarding infection control in Bulgaria

Study Design: Between July 2024 and March 2025, a descriptive cross-sectional study was conducted to assess the knowledge, attitudes, and practices of dental technicians in Bulgaria regarding infection control. The target population comprised dental technicians actively practising in dental laboratories nationwide.

The design and reporting of the study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for cross-sectional studies (von Elm et al., 2007), ensuring robust methodology and transparent presentation of this descriptive epidemiological research.

Participant Selection Sampling Frame:

The study utilized the official register of the Bulgarian Association of Dental Technicians (BADT), which, at the time of the research, included 1,200 dental technicians across 28 regional branches in Bulgaria. As of 2024,

membership in the BADT is a mandatory legal requirement for all practising dental technicians in the country.

Inclusion Criteria:

Participants were eligible for inclusion if they:

- were actively practising as dental technicians in Bulgaria at the time of the study;
- provided written informed consent to participate in the study.

Exclusion Criteria

Participants were excluded if they:

- were not practising as dental technicians at the time of the study and/or were not practising in Bulgaria;
- declined to participate.

Sample Size Determination

The sample size was calculated using G*Power software (version 3.1), following the protocol for a one-sample binomial test comparing a sample proportion to a constant value. The parameters applied were as follows: a two-tailed test, effect size *(g):* 0.10, α =0.05, statistical power $(1-\beta)$ = 0.80, and a hypothesized proportion**:** 0.50. The choice of a hypothesized proportion of 0.50 represents a conservative approach, reflecting the absence of prior national data on the subject under investigation.

The minimum required sample size was determined to be 199 respondents, representing approximately 17% of the dental technicians registered with the BADT at the time of the study.

Research Instrument

Predicated on an extensive review of the scientific literature concerning the issue, a self-administered online questionnaire was developed for this study.

The research instrument was designed to assess dental technicians' awareness of cross-infection risks and infection-control measures, their attitudes towards existing infection control recommendations, and the adherence of their clinical-laboratory practices to internationally recognised

cross-infection control protocols. The survey's knowledge, attitudes, and practices (KAP) section employed a structured, closed-ended format, comprising five multiple-choice items, two Likert-scale items, and fifteen dichotomous (yes/no) items.

The final instrument consisted of 28 items in total, organised into four thematic sections:

1. *Awareness of Infection Control (5 items):* This section addressed participants' self-reported and objective awareness of cross-infection control; familiarity with existing infection control protocols within the laboratory and first-aid procedures for needlestick or sharps injuries; and participation in postgraduate training related to infection control in professional practice.
2. *Infection Control Practices (13 items)*: This section evaluated key aspects of infection control, encompassing: the implementation of routine infection control practices, such as the disinfection of dental impressions and other clinical materials; the use of personal protective equipment (PPE); adherence to hand hygiene; hepatitis B virus (HBV) vaccination status; clinic-to-laboratory communication regarding the disinfection of items in transit; and the presence of a designated receiving area for the disinfection of materials within laboratory facilities, in accordance with CDC recommendations.
3. *Attitudes Towards Infection Control (4 items):* This section addressed the participants' self-perceived occupational risk of infection, the necessity for continuing professional training in infection control, the feasibility of implementing specific control measures, and the financial burden associated with regulatory compliance.
4. *Participants' Sociodemographic Characteristics (6 items)*: This section collected information on participants' sex, age, and length of professional experience in years (open-ended responses); geographical location of practice (capital/regional city versus small town/rural area); size of the laboratory (open-ended, including the number of employees); and the respondent's professional role (laboratory owner/manager or employee).

Primary Data Collection Methods:

The questionnaire was distributed and completed online using the Google Forms platform, allowing participants to submit their responses

electronically. Responses were automatically aggregated and securely stored in the researcher's Google Forms account.

The following multi-channel recruitment strategy was employed for primary data collection:

- Individual written invitations containing a survey link were disseminated via email to potential respondents - practising dental technicians (160 emails);
- Personalised direct messages were sent to potential respondents via the Viber application (290 messages);
- Following administrative approval, public invitations were posted on two official professional networking platforms dedicated to the target groups: *Dental Technology* and *Dentistry and Dental Technology*;
- Survey links were distributed to faculty members at the Medical Colleges of Sofia, Plovdiv, and Varna, via institutional email addresses publicly listed on the official websites of their respective institutions.

Institutional support for disseminating the questionnaire among the target professional group was sought and provided by the Chair of the Bulgarian Association of Dental Technicians.

4.4. Study on disinfection and communication practices of dental practitioners regarding infection control in dental offices and dental laboratories

Study Design

Between July 2024 and March 2025, a survey was conducted among dental practitioners to assess disinfection and communication practices related to infection control.

Participant Selection Sampling Frame:

The official Dental Healthcare Facilities Register maintained by the Regional Health Inspectorate (RHI) of Varna. This database contains comprehensive contact information for all registered dental practitioners within the region.

Inclusion Criteria:

Participants were eligible for inclusion if they:

- were actively practising as dental practitioners in Bulgaria at the time of the study;
- provided written informed consent to participate in the study.

Exclusion Criteria

Participants were excluded if they:

- were not practising as dental practitioners at the time of the study and/or were not practising in Bulgaria;
- declined to participate.

Research Instrument

A self-administered online questionnaire was developed for this study.

The research instrument was designed to assess disinfection protocols used by dental practitioners for clinical materials transferred between dental offices and dental laboratories, while also evaluating the associated communication between these settings. The survey employed a structured, closed-ended design, comprising two multiple-choice items, one Likert-scale item, and five dichotomous (yes/no) items.

The final instrument consisted of 13 items in total, organised into three thematic sections.

1. *Awareness of Cross-Infection Control Measures and Communication with the Dental Laboratory (3 items):* This section addressed participants' self-assessment of their awareness regarding cross-infection control measures and the methods of communication with dental laboratories concerning the disinfection of materials transported between the two healthcare settings.

2. *Infection Control Practices (5 items):* This section addressed key aspects including: disinfection protocols for materials exchanged with dental laboratories; procedures for packaging and handling materials during transfer; and the presence of a designated infection control coordinator within the dental office;

3. *Participants' Sociodemographic Characteristics (5 items):* This section collected information on participants' sex, age, and length of professional experience in years (open-ended responses); geographical location of practice (capital/regional city versus small town/rural area); size

of the dental facility (open-ended, including the number of employees); and the respondent's professional role (laboratory owner/manager or employee).

The questionnaire was distributed and completed online using the Google Forms platform, allowing participants to submit their responses electronically.

The following multi-channel recruitment strategy was employed for primary data collection:

- Individual written invitations containing a survey link were disseminated via email to potential respondents - practising dental practitioners (270 messages);
- Personalised direct messages were sent to potential respondents via the Viber application (215 messages);
- Following administrative approval, public invitations were posted on two official professional networking platforms dedicated to the target groups: *Dental Technology* and *Dentistry and Dental Technology*.
- Survey links were distributed to faculty members at the Medical Colleges of Sofia, Plovdiv, and Varna, via institutional email addresses publicly listed on the official websites of their respective institutions.

4.5. Statistical methods for data processing and quantitative analysis

The selection of statistical methods was dictated by the specific research objectives, the nature of the variables, and their measurement scales.

For the descriptive analysis of participants' demographic characteristics, qualitative variables were summarized using absolute frequencies and relative percentages. Quantitative variables were presented as mean ± standard deviation or as median with interquartile range (IQR), following a preliminary assessment of data distribution normality using the Kolmogorov–Smirnov test.

Research hypotheses were evaluated using a combination of the following statistical methods:

- Non-Parametric Analysis: Chi-square test (χ^2) and Fisher's exact test.

- Parametric Testing: One-sample *z*-test, Student's *t*-test for independent samples, and one-way ANOVA for comparing means across multiple groups.
- Predictor Analysis: To identify determinants of optimal infection control practices among dental technicians, simple and multiple linear regression analyses were performed. Only variables demonstrating a statistically significant association with the dependent variable in the simple regression phase were included in the final multiple regression model. Dummy coding was applied to qualitative predictors prior to their inclusion in the models.
- Descriptive and graphical analyses were used to illustrate the findings through tables and figures.

Data were initially entered into Microsoft Excel. Statistical analyses were conducted using IBM SPSS Statistics (v.23), and graphs were produced in Excel.

RESULTS AND DISCUSSION

1. International policies and guidelines for infection prevention and control in dentistry: A focus on dental laboratories

Infection control recommendations for dental laboratories have evolved into an integral component of broader frameworks for infectious risk management in dental healthcare settings. Driven by advancements in science and technology, and in response to significant public health events, these measures have progressed from early guidance focused primarily on the disinfection of dental prosthetic appliances to comprehensive guidelines for infection prevention and control in laboratory practice (CDC, 2003).

1.1 Key international and national organizations influencing the development of infection control guidelines in dental settings

1.1.1 Centres for Disease Control and Prevention (CDC), USA

The Centres for Disease Control and Prevention (CDC), as the preeminent authority in the United States responsible for disease prevention, is directly engaged in the development of evidence-based guidelines and best

practice recommendations, specifically regarding infection control in dental healthcare settings.

The HIV/AIDS epidemic served as a primary catalyst for the CDC to reassess infectious risk within the medical field, and in dental practice specifically, leading to the 1985 introduction and subsequent formalization of the *Universal Precautions* concept, advocating that all patients be considered as potentially infectious (Fulford & Stankiewicz, 2020). The core elements of these *universal precautions* include hand washing, the mandatory use of personal protective equipment (PPE) - specifically gloves, masks, and protective eyewear; the prevention of injuries caused by needles, scalpels, and other sharp instruments; and the implementation of standardized disinfection and sterilization procedures (CDC, 1987).

An important conceptual shift for dental professionals was the recognition that blood and other body fluids, including saliva, must be regarded as potentially infectious for pathogens such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV), the transmission of which is associated with occupational exposure (Molinari J, 2003).

In 1986, the Centres for Disease Control and Prevention (CDC) published *Recommended Infection-Control Practices for Dentistry* (CDC, 1986), which formally introduced the concept of *universal precautions* into dental healthcare settings (Molinari et al., 2010). Although the document did not provide extensive guidance specifically for dental laboratory practice, it formulated essential recommendations for the decontamination of laboratory supplies and materials. Furthermore, it underscored the critical importance of communication between the dental office and the dental laboratory regarding disinfection procedures. Particular emphasis was placed on the disinfection of impressions, prosthetic appliances, and other intraoral devices prior to their transfer to the laboratory and before their subsequent placement in the patient's mouth.

A decade later, in 1996, the CDC expanded the scope of the *Universal Precautions* and transitioned to the term *Standard Precautions* (Harte, 2010). These evolved into a standard for healthcare and dental delivery, designed to protect both healthcare professionals and patients from pathogens transmissible through blood or other body fluids. *Standard Precautions* must be applied during contact with: 1) blood; 2) all body fluids,

secretions, and excretions (with the exception of sweat), regardless of whether they contain visible blood; 3) non-intact skin; and 4) mucous membranes.

The core elements of standard precautions for all healthcare settings include: 1) Hand hygiene; 2) Use of personal protective equipment; 3) Prevention of injuries from sharps and cutting instruments; 4) Safe injection practices; 5) Cleaning, disinfection, and sterilization of medical equipment and the environmental surfaces; 6) Respiratory hygiene and cough etiquette.

In 2003, the CDC updated its infection control guidelines for dentistry, incorporating a dedicated "Special Considerations" section for dental laboratories. The recommendations include:

- Disinfection of dental prostheses, appliances, and items used in their fabrication (e.g., impressions, bite registrations, etc.);
- Cleaning, disinfection, and sterilization of instruments, equipment, and environmental surfaces;
- Coordination and communication between the dental office and the laboratory to ensure appropriate disinfection, avoid redundant processing that may damage materials, and clearly define responsibility for final disinfection;
- Provision of written documentation regarding the specific disinfection methods used (e.g., type of disinfectant and exposure time) when cases are sent to off-site laboratories;
- Establishment of a dedicated receiving and disinfection area, separate from the production and fabrication zones;
- Mandatory use of personal protective equipment (PPE);
- Proper management of regulated waste generated within the laboratory;
- Comprehensive training of laboratory personnel on infection control programs, accompanied by clearly written policies and Standard Operating Procedures (SOPs).

In 2016, the CDC published the *Summary of Infection Prevention Practices in Dental Settings: Basic Expectations for Safe Care* (CDC, 2016). This document serves as a streamlined synthesis of the 2003 guidelines, reaffirming *Standard Precautions* as the foundational requirement for

preventing the transmission of infectious microorganisms during the delivery of dental care.

The CDC's 2003 Guidelines and the 2016 Summary represent comprehensive, evidence-based frameworks for infection control practices applicable across all dental healthcare settings that are designed to ensure the protection of both dental healthcare personnel and their patients.

1.1.2 American Dental Association (ADA)

The first specific report on infection control in dental offices was published by the ADA in 1978 (ADA, 1978).

The document centred on clinical recommendations, including: 1) patient medical histories to identify potential carriers of infectious disease; 2) cleaning, disinfection, and sterilization of instruments and surfaces; 3) use of physical barriers, such as gloves, masks, and protective eyewear; 4) procedures to minimize the spread of microorganisms; and 5) the use of single-use disposables and maintenance of dental unit waterlines.

While primarily clinically focused, the ADA was the first to provide a brief recommendation for dental laboratories, specifically advising the cleaning of prosthetic appliances before procedures that generate aerosols and the use of shields and air evacuation systems during laboratory work.

In subsequent updates to the guidelines, the ADA provided significantly more detailed recommendations for dental laboratories, encompassing various aspects of laboratory practice such as sterilization protocols, personal protective equipment (PPE), regulated waste management, etc.

In 1985, in response to the CDC's *Universal Precautions*, the ADA published the first comprehensive guidelines specifically addressing infection control in both the dental office and the dental laboratory (ADA, 1985). Prior to this publication, infection control within dental laboratories had not been systematically regulated (including by the CDC). The ADA formulated four primary objectives for these infection control programmes:

- To reduce the microbial load to a level at which the body's normal defence mechanisms can prevent infection;
- To break the cycle of transmission and eliminate cross-contamination;
- To treat every patient and every instrument as a potential carrier of infectious disease (treating all patients and items as potentially infectious);

- To protect patients and personnel from infection and its consequences, while also shielding the dental team from the threat of litigation.

In the subsequent 1988 update, the ADA introduced pivotal changes to its recommendations (ADA, 1988). Detailed checklists for key infection control practices were included for both the dental office and the dental laboratory to facilitate proper adherence to the requirements by dental healthcare personnel.

The recommendations for dental laboratories were restructured to follow the logical workflow of the facility: receiving area, incoming cases, use of protective attire and barrier techniques, waste management, production area, and outgoing cases.

New recommendations were formulated, including: 1) designation of a dedicated receiving and disinfection station for materials, physically separated from the work area; 2) sterilization and disinfection of polishing brushes; 3) use of unit-dosing for pumice (utilizing individual portions for each case); and 4) waste management protocols. Furthermore, a new recommendation was issued regarding bilateral dental office-laboratory communication, recommending that laboratories proactively inform dentists of their internal infection control protocols. While the ADA urged dental laboratories to implement formal infection control programmes, the 1992 update added the requirement that these programmes be coordinated with the dental office (ADA, 1992).

In 1996, the ADA updated its infection control guidelines once more, though no significant changes were made to the recommendations for dental laboratories. A new recommendation for dental offices, which also concerned dental laboratory practice, was the requirement for labelling disinfected impressions sent to the laboratory to avoid duplication of disinfection procedures.

Later, the ADA recognized and supported the infection control guidelines for dental settings issued by the CDC in 2003 and in their 2016 Summary. The Association has also published practical guides to assist practitioners in complying with these requirements, most recently updated in response to the COVID-19 pandemic.

1.1.3 World Dental Federation (FDI)

A significant milestone in the development and evolution of global international guidelines for infection control in dentistry was the *Policy Statement on Infection Prevention and Control in Dental Practice,* ratified during the 2009 FDI World Dental Federation General Assembly in Singapore. Most recently updated in 2021, this policy has been adopted by all FDI member organizations, including the Bulgarian Dental Association.

The FDI advocates for the strict implementation of standard precautions (as formulated by the CDC) across all oral health teams and urges dental professionals to take appropriate measures to mitigate infectious risks to patients, staff and themselves through:

- Utilising risk-based physical protection during clinical interventions;
- Maintaining an awareness of occupational health issues related to the prolonged use of personal protective equipment (PPE);
- Prioritising immunisation against vaccine-preventable infectious diseases;
- Conducting rapid clinical testing and assessment to determine the need for post-exposure prophylaxis following occupational contact with blood borne pathogens, specifically HBV, HCV, and HIV;
- Ensuring personal awareness of the signs and symptoms of blood borne and other infectious diseases, and seeking diagnostic screening whenever a potential infection is suspected.

An important stage in the evolution of global international policies for infection control was the publication of the *Policy Statement on Dental Laboratory Technicians*, first adopted in Spain in 1998 and most recently revised in 2024 in Istanbul. This document emphasises the necessity of lifelong learning and continuous professional development of dental practitioners, specifically targeting the regular updating of dental technicians' expertise in infection control protocols.

1.1.4 World Health Organization (WHO)

In 2016, the WHO published the first international evidence-based guidelines on the *Core Components of Infection Prevention and Control Programmes* (WHO, 2016).

Subsequently, in May 2022, the Seventy-fifth World Health Assembly adopted a comprehensive global strategy: the *Global Strategy on Infection Prevention and Control 2023-2030*. This strategy focuses on combating infectious diseases in every setting where healthcare is delivered, across the entire continuum of the healthcare system. It emphasises the necessity of fostering a safety culture, securing resources, and providing personnel training, regardless of the type of health facility (WHO, 2023).

During the COVID-19 pandemic, the WHO published specific guidance for the dentistry sector entitled *Considerations for the Provision of Essential Oral Health Services* (WHO, 2020); however, there is no separate document specifically targeting dental laboratories.

1.2. Influence of European professional and health organisations on the evolution of infection control standards in dental practice

1.2.1. European Centre for Disease Prevention and Control (ECDC)

During public health emergencies, such as the COVID-19 pandemic, the European Centre for Disease Prevention and Control issued specific guidance for dental settings, addressing the physical distancing measures for patients and the appropriate use of personal protective equipment by healthcare personnel, particularly during aerosol-generating procedures (ECDC: Stockholm, 2020).

In addition, the ECDC compiled a comprehensive list of countries that have adopted national guidelines for infection prevention and control in dentistry, several of which are available in English. These include Austria, Belgium, Germany, Greece, Hungary, Ireland, Norway, Poland, Switzerland, and the United Kingdom (ECDC, 2018).

1.2.2. British Dental Association (BDA)

In 1991, the British Dental Association (BDA) issued concise advice entitled *Control of Cross-Infection in Dentistry*, developed in collaboration with the Department of Health of England (Nield, 2020). This document set out safe and practical infection control measures for general dental practice and became one of the most widely consulted resources of its time (Nield, 2020). It was subsequently updated in 2003 (BDA, 2003).

In the late 1990s, the emergence of variant Creutzfeldt-Jakob Disease (vCJD) in the United Kingdom, linked to the consumption of contaminated beef, created a significant public health crisis and prompted a major paradigm shift in infection control within dentistry (Fulford & Stankiewicz, 2020). The detection of the infectious agent in animal dental pulp led to the development of the first comprehensive infection control guidance for dentistry in the United Kingdom: *Health Technical Memorandum 01-05: Decontamination in Primary Care Dental Practices* (HTM 01-05). Originally published in 2009 by the Department of Health, it was later revised in 2013 (Department of Health, 2013).

Chapter 7 of HTM 01-05 sets out recommendations for dental practice concerning the decontamination of impressions, dentures, and orthodontic appliances. Detailed procedures are provided for disinfection and for the labelling of decontaminated materials prior to their dispatch to the dental laboratory. However, the document does not include specific guidance addressing the internal processes of dental laboratories.

3. Regulatory framework governing the prevention and control of infections in dental laboratories in Bulgaria

The profession of dental technician was formally recognised as a regulated healthcare profession in Bulgaria under Council of Ministers Decision No. 925 of 29 December 2006. The legislation acknowledges the professional significance of the role and establishes the regulatory oversight necessary to safeguard public health.

The fabrication of dental prosthetic devices in Bulgaria is governed by Ordinance No. 1 of 8 February 2011. Pursuant to Article 2(2) of the Ordinance, dental technicians are legally authorised to carry out preparatory procedures, manufacture, and repair medical devices in accordance with a prescription from a physician and/or a dental practitioner.

To practice as a dental technician in Bulgaria, individuals must obtain a higher education degree in the specialty of Dental Technology, within the professional field 7.5. Healthcare, which confers the academic degree of Professional Bachelor. Since 2019, following the establishment of a statutory professional body for dental technicians, membership in the Bulgarian Association of Dental Technicians (BADT) has become a mandatory prerequisite for professional practice. This requirement is

stipulated under the *Professional Organisations of Nurses, Midwives, and Associated Medical Specialists, Physician Assistants, Dental Technicians, and Assistant Pharmacists Act (2005)*.

Dental technicians operate within Independent Medical-Technical Laboratories (IMTLs), which are formally classified as outpatient healthcare facilities under the *Medical Establishments Act (1999)*.

The provision of dental technology services in Bulgaria is governed by Ordinance No. 30 (19 December 2003), issued by the Minister of Health, which establishes the Medical-Technical Standard for Dental Technology. This standard serves as the principal framework for clinical governance in the sector, stipulating that:

"*All Medical-Technical laboratories engaged in dental technology activities must operate in full compliance with the Medical and Technical Standard for Dental Technology*."

The general requirements for dental technology practice, as outlined in Section IV of the Standard, state that: „*the dental technician shall employ methods and systems throughout the workflow that positively impact patient health and safety, thereby reducing the risk of infection and cross-contamination".* Section IV also includes specific provisions addressing infection prevention and control (IPC) within the laboratory setting, including:

Subsection 1.5: The dental technician shall wear appropriate professional attire and implement necessary precautionary measures.

Subsection 1.10: The dental technician shall dispose of waste in suitable containers, ensuring no risk of environmental contamination.

Subsection 1.11: The dental technician shall have access to materials and equipment necessary for the disinfection procedures and the preparation of dental casts (models).

Regarding the disinfection of impressions, Section IV, Item 2.2 of the standard stipulates that the dental technician must *"disinfect the impression before it is assessed as suitable."* This implies that all impressions must undergo disinfection, regardless of their final clinical viability. Furthermore, when producing situational models, the technician is instructed to **"***handle the impression in a way that limits the risk of infection or deformation."* However, the standard provides no specific guidance on how to minimize infection risk without causing material deformation.

Consequently, it appears that the dental technician is faced with a choice: follow a process that prevents deformation or one that eliminates the risk of infection.

The Medical-Technical Standard outlines requirements for the disinfection of dental impressions, prosthetic devices, and orthodontic appliances as follows: all incoming materials must be cleaned and disinfected upon receipt from the dental office; however, the standard provides no specific details on how these procedures should be performed. Similarly, upon completion of the fabrication process, the items must be cleaned, disinfected, and packaged *"safely for delivery, together with the instructions for the patient/client."*

The standard provides no recommendations concerning the selection of disinfectants suitable for different materials, nor does it set out requirements for the labelling of items prepared for dispatch. Moreover, it leaves undefined both the concept of *"safely for delivery"* packaging and the information that should be included in the *"instructions for the patient/client."*

The ADA issues a recommendation for the disinfection of pumice slurry used for polishing dentures (ADA, 1996). Also, the CDC recommends that polishing brushes used on contaminated or potentially contaminated dentures and other materials be heat-sterilized, disinfected between laboratory cases, or that disposable ones be used (CDC, 2003). Guidelines with such a focus are absent from the Medical-Technical Standard.

The American Dental Association (ADA) recommends the disinfection of pumice slurry used in the polishing of dentures (ADA, 1996). Similarly, the Centres for Disease Control and Prevention (CDC) advises that polishing brushes used on contaminated or potentially contaminated dentures and other prosthetic materials should either be heat-sterilized, disinfected between laboratory cases, or replaced with single-use (disposable) alternatives (CDC, 2003). Comparable guidance addressing these specific laboratory procedures is absent from the Medical-Technical Standard for Dental Technology.

A more recent Bulgarian regulatory instrument addressing the protection of patients and healthcare personnel from healthcare-associated infections is the Medical Standard for the Prevention and Control of

Healthcare-Associated Infections. This was adopted by Ordinance No. 3 of 8 May 2013 issued by the Minister of Health.

The standard conceptualizes infection control through two primary categories: standard precautions and additional (isolation/barrier) precautions.

According to the Standard, outpatient care facilities (including dental laboratories) are required to implement and maintain an annual comprehensive programme for the prevention and control of Healthcare-Associated Infections (HAIs) and the containment of antimicrobial resistance (AMR). This programme must encompass:

1. Risk assessment of infections for patients, third parties, and staff, including evaluation of immune status and measures to mitigate identified risks (e.g., immunisation, use of personal protective equipment, etc);
2. Measures for enhancing staff qualification in the field of infection control;
3. Rules and procedures governing:
   3.1. the use of personal protective equipment;
   3.2. aseptic techniques in the provision of patient care;
   3.3. the processing, disinfection, and sterilisation of reusable medical devices and equipment;
   3.4. post-exposure prophylaxis, including procedures following exposure to blood and body fluids and the handling of sharps;
   3.5. the prevention, reporting, and management of sharps injuries;
4. A disinfection policy, covering skin, surfaces, and instruments;
5. Management of medical waste;
6. A policy for limiting the spread of AMR, including:
   6.1. the empirical antibiotic use and surgical antibiotic prophylaxis;
   6.2. the collection and transport of specimens for microbiological testing.

Section VIII of the Standard sets out specific requirements for the prevention and control of healthcare-associated infections in dental practice. The key requirements encompass aspects such as: mandatory standard precautions, hand hygiene, use of personal protective equipment, processing

and sterilisation of dental instruments, surface disinfection, waste management, post-exposure prophylaxis, and others.

In contrast to the United States, where the CDC issued a standalone document for dental practice in 2003 (CDC, 2003), providing detailed procedure-specific guidance on implementing standard precautions in dental settings (including dental laboratories), the Bulgarian general medical standard for prevention and control of healthcare-associated infections addresses the specific requirements for dental practice consolidated into a single section of the broader framework, comprising 21 points across approximately 8 pages. What is notable is the complete absence of specific requirements for dental laboratories.

Dental laboratory activity is mentioned twice - first when describing indirect contact with "dental laboratory materials" as one of the most important potential transmission routes in dental practice, and second in relation to “decontamination of dental impressions, dentures, bridges and other materials, which is described as being performed - “as a rule” - immediately after removal from the patient’s oral cavity, following the sequence: rinsing under running water (or in an ultrasonic bath) -> followed by disinfection according to manufacturer's instructions (using a CE-marked product; sodium hypochlorite (household bleach) may not be suitable!). Beyond these references, the standard provides no further discussion of dental laboratory activity.

The Centers for Disease Control and Prevention (CDC) likewise recommends that the decontamination of impressions and other prosthetic materials be performed immediately after their removal from the patient's oral cavity (CDC, 2003). Unlike the Bulgarian Standard for the Prevention and Control of HAIs, however, the CDC adds that when a laboratory case is transferred outside the facility, dental personnel must provide written documentation describing the cleaning and disinfection procedures that have been performed.

Variations in decontamination protocols are further highlighted when comparing the Bulgarian regulatory framework to CDC guidance. While the Bulgarian Standard for the Prevention and Control of HAIs mandates a two-step sequence to decontaminate impressions, dentures, bridges, and other materials - (1) rinsing under running water and (2) disinfection in accordance with the manufacturer’s instructions - the CDC prescribes that such items be

thoroughly cleaned (i.e., visibly contaminated blood and bioburden removed), then disinfected using an Environmental Protection Agency (EPA)-registered tuberculocidal hospital disinfectant, and finally rinsed thoroughly prior to laboratory processing (CDC, 2003).

The Bulgarian Standard for Prevention and Control of HAIs does not establish requirements regulating communication between dental laboratories and the dental practices with respect to the disinfection procedures applied to materials transported between the two healthcare settings. The CDC, by contrast, recommends that when cases are sent to off-site laboratories (whether a dental office or a dental laboratory), dental healthcare personnel provide written documentation specifying the methods of disinfection used (e.g., type of disinfectant and exposure time) (CDC, 2003). Furthermore, the CDC emphasizes that effective communication between the dental clinic and the laboratory is essential for clearly establishing responsibility for the final cleaning and disinfection of prosthetic devices prior to delivery to the patient.

The currently applicable hygienic requirements governing the premises of Medical-Technical Laboratories (MTLs) and the implementation of an anti-epidemic regime within them were approved by Order No. РД-09-325 of 4 April 2000 of the Minister of Health. These requirements are organised into two sections: Section I, which sets out general provisions, and Section II, which establishes specific requirements applicable to MTLs. The general provisions regulate the types of buildings in which healthcare establishments may be located, the categories and minimum floor areas of work premises, as well as construction and installation requirements.

Point 4.1.4 specifies the premises designated for dental technical activities, including: a room for routine dental technical work; a room for polishing, flask heating, and casting; and a room for metal-ceramic processing. Point 4.3 further defines the mandatory minimum of auxiliary premises, which include, inter alia, a sterilisation room.

The functional and spatial planning requirements applicable to Medical-Technical Laboratories (MTLs) are set out in Ordinance No. РД-02-20-3 of 21 December 2015 (promulgated in State Gazette No. 5/2016, corrected in No. 13/2016, and amended and supplemented in No. 78/2020) on the design, construction, and maintenance of public service buildings in the sectors of education and science, healthcare, culture, and the arts. Pursuant to

Article 117(1) and (2), an MTL must comprise designated areas for routine dental technical work, for polishing and flask heating, and for metal-ceramic processing. The ordinance permits the integration of a dedicated metal-ceramics workstation within the main room for routine dental technical activities. Notably, the regulation does not require the establishment of a separate disinfection area within the laboratory, in contrast to the recommendations issued by the Centers for Disease Control and Prevention (CDC).

Although all constituent elements of standard precautions are addressed within the broader Bulgarian regulatory framework, the relevant guidance and requirements governing dental technical practice are dispersed across multiple regulatory documents. This fragmentation may hinder coherent interpretation and effective implementation, particularly in the absence of continuing professional training.

2. Descriptive review of global studies on dental technicians' knowledge, attitudes, and practices regarding infection control in professional practice

While infection prevention and control (IPC) is of paramount importance for the health of both patients and dental professionals, it has remained relatively under-researched internationally; nonetheless, the volume of literature in this field has grown steadily in recent years. A total of 28 studies from diverse geographical regions were identified. The distribution of these publications across the periods of 2000–2007, 2008–2015, and 2016–2023 is uneven, with numbers increasing in each consecutive interval.

Of all the identified studies, the largest proportion (n = 13) were conducted in Asia, with the first published study originating from Jordan (Al-Dwairi, 2007). Studies from Africa (n = 6) were conducted across four countries, the earliest being from Egypt (El-Kholy & Sedky, 2012). Notably, the earliest studies identified within the overall review period were conducted in Brazil and the United States (Campanha et al., 2004; Kugel et al., 2000). European studies (n = 7) were carried out in six countries, including Bulgaria.

The primary study design was cross-sectional, with most studies employing relatively small sample sizes. At the individual level, sample sizes ranged from 11 to 200 dental technicians, 48 to 193 dentists, and 15 to 400

dental laboratory managing directors. At the institutional (group) level, samples included between 20 and 96 dental laboratories.

There is a noticeable dynamic in the research topics addressed over the study period. Early literature centred primarily on basic practices for disinfection of impressions and prosthetic appliances, the use of Personal Protective Equipment (PPE), Hepatitis B vaccination among laboratory technicians, and the effectiveness of clinic-to-laboratory communication regarding disinfection protocols.

In contrast, more recent research has broadened its focus, increasingly examining aspects such as surface disinfection, the sterilization of instruments, the establishment of designated receiving and disinfection areas, and standardized packaging protocols for impressions dispatched between the clinic and the laboratory.

Within the third timeframe (2016–2023), some of the studies exhibit a heightened emphasis on the use of PPE in high-aerosol and splash-generating zones, specialized laboratory waste disposal systems, the existence of written infection control protocols, and the availability of training courses for dental technicians.

From the perspective of knowledge, attitudes, and practices (KAP) regarding infection control in the dental laboratory, the research questions can be conceptualized into three primary categories: those assessing knowledge/awareness, those evaluating attitudes/perceptions, and those measuring actual practices.

The level of knowledge among dental technicians is evaluated through inquiries into their familiarity with IPC recommendations, regulations, and standards. This category also includes items addressing the existence of written disinfection protocols within the laboratory, periodic infection control training, and theoretical understanding related to disinfection and sterilization of clinical materials, prosthetic constructions, work surfaces, instruments, and equipment. In addition, the category encompasses questions exploring respondents' awareness of communication procedures between the dental clinic and the laboratory regarding the disinfection of clinical materials: including how this process is organized and its informational contents.

Attitude-related questions target the dental technicians' self-assessment of occupational infection risk, the perceived importance of risk-

reduction measures, assessment of their implementation, and perception of these measures as a financial burden on the laboratory budget.

Practice-related questions examine the implementation of specific precautionary measures, the extent to which they are integrated into routine operations, and their compliance with established infection control guidelines.

3. Results of the study on knowledge, attitudes, and practices of dental technicians regarding cross-infection control in dental laboratories

The final sample comprised 203 dental technicians, accounting for approximately 17% of all technicians registered with the professional association of dental technicians in Bulgaria at the time of the study. Socio-demographic characteristics of the respondents are presented in Table 1.

Table 1. Socio-demographic characteristics of the study population (n=203)

Characteristics	**Total n (%)**	**Men n (%)**	**Women n (%)**	**p-value**
Sex	203 (100.0)	104 (51.2)	99 (48.8)	
Age (years), median (IQR)	35 (28–48)	39.6 (11.2)	37.1 (13.1)	0.144
Clinical experience (years), median (IQR)	11.5 (4.8–24)	15.3 (10.4)	13.9 (12.9)	0.337
Position in the Laboratory				
Manager / Owner	70 (34.5)	39 (37.5)	31 (31.3)	0.354
Employee	133 (65.5)	65 (62.5)	68 (68.7)	
Geographic Location of the Laboratory				
Capital / Regional Centre	191 (94.1)	97 (96.0)	94 (96.9)	0.741
Small Town / Village	7 (3.4)	4 (4.0)	3 (3.1)	
Laboratory Size				
Small (1–2 technicians)	81 (40.9)	43 (41.7)	38 (40.0)	0.897
Medium (3–5 technicians)	78 (39.4)	41 (39.8)	37 (38.9)	
Large (6+ technicians)	39 (19.7)	19 (18.4)	20 (21.1)	

Participants were evenly distributed by sex. Statistical analysis revealed no significant differences between males and females in terms of age (p = 0.144) or length of professional experience (p = 0.337). Geographically, the majority of respondents were based in the capital or in large urban areas with populations exceeding 100,000 inhabitants.

Most respondents worked in laboratories employing up to five dental technicians. Mean professional experience was 10+ years, with approximately one-third holding managerial positions. Male respondents were overrepresented in leadership roles (37,5%).

The research findings are organized into three main sections corresponding to the components of the data collection instrument: (1) awareness of cross-infection risks and control measures; (2) infection control practices within the laboratory; and (3) attitudes toward infection control.

Awareness of Cross-Infection Risks and Control Measures

- ***Self-assessment of infection control awareness***

Slightly more than half of the respondents (54.8%) rated their level of awareness regarding cross-infection control as "very good" or "excellent", whereas only 3.0% reported a low level of knowledge concerning preventive measures.

Dental technicians aged 35 and above were more likely to report higher levels of self-assessed knowledge, whereas younger participants (under the age of 35) more frequently rated their knowledge as low (χ^2 = 11.135, df = 4, p = 0.025).

- ***Assessment of theoretical knowledge on infection control***

Two-thirds of the respondents (75.2%) correctly identified the definition of cross-infection (Figure 1).

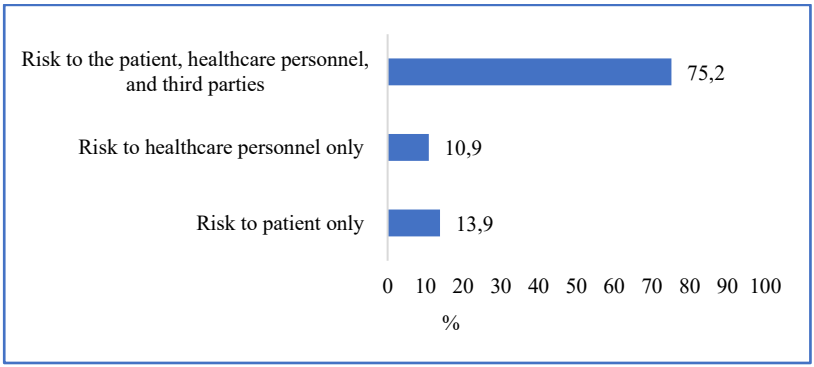

Figure 1. Definition of Cross-Infection

The association between awareness of the term *cross-infection* and self-assessed level of knowledge regarding infection prevention and control (IPC) was statistically significant (χ^2 = 16.091, df = 4, p = 0.003). Respondents with high self-rated awareness ("excellent" or "very good") were most likely to provide a comprehensive definition of *cross-infection*, identifying it as a risk to patients, healthcare personnel, and third parties. A similar association was observed between knowledge of the *cross-infection* concept and sex (χ^2 = 10.052, df = 2, p = 0.007). A higher proportion of female respondents defined the term correctly (78.6%) compared to their male counterparts (72.1%). Interestingly, men were more likely to perceive cross-infection as a risk primarily to healthcare personnel (17.3%), whereas women were more inclined to view it as a risk solely to the patient (17.3%). No significant associations were found with respect to age, professional role, or geographic location of the laboratory.

- ***Postgraduate training in infection control***

Despite the high level of self-assessed awareness regarding infection IPC, fewer than 20% of dental technicians reported having received postgraduate training on the subject after completing their formal education. Only 12 respondents (5.9%) indicated that they had attended such training within the previous year.

The analysis of the relationship between postgraduate training and the variables of age and professional experience revealed statistically significant differences between the compared groups. Nearly all technicians who had undergone IPC training during the preceding year had limited professional experience (up to 4 years). In contrast, only 9.2% of the more experienced participants (those with over 15 years of professional experience) reported having ever attended such training, with only one individual (1.2%) confirming that it had taken place within the previous year (χ^2 = 24.242, df = 6, p = 0.001). Similarly, statistically significant differences were observed in relation to participants' age and postgraduate IPC training (χ^2 = 10.968, df = 4, p = 0.025).

Almost all technicians aged over 50 years (95.2%) reported that they had never received such type of training. Younger respondents (aged 34 or under) reported more frequently that they had attended infection control training. Given that the Bulgarian Association of Dental Technicians (BADT)

has not established a structured system for continuing professional training for dental technicians, it is most likely that the training reported by younger respondents refers to mandatory safety and infection control inductions provided upon commencement of employment rather than to formal postgraduate continuing education programmes.

- ***Awareness of written laboratory infection control protocols***

When questioned regarding the existence of written protocols addressing key areas of infection prevention and control within their laboratories, participants demonstrated a low level of awareness. This was particularly evident regarding occupational post-exposure policies (9.9%) and sharps safety protocols (19.7%) (Figure 2).

A considerable proportion of respondents (17.2%) reported that they were not aware of the existence of any of the specified protocols at their workplace.

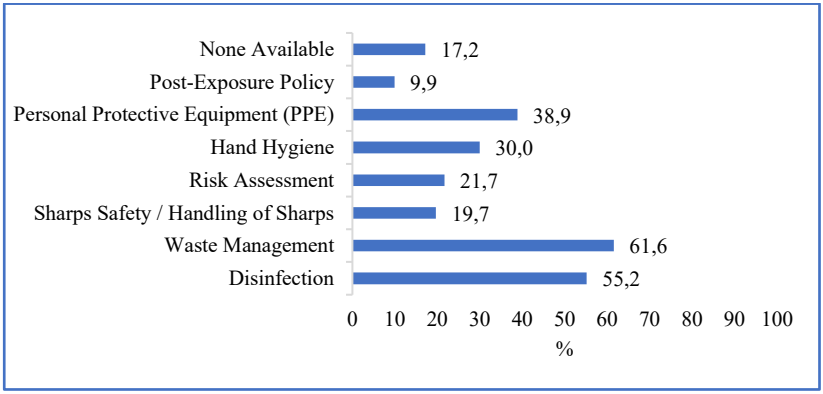

Figure 2. Awareness of the existence of written IPC protocols and procedures in the laboratory

- ***Waste management procedures***

The highest level of awareness was observed with regard to the waste management procedures (61.6%). Laboratory employees were significantly more familiar with them (69.9%) compared to laboratory managers/owners (45.7%) ($\chi 2 = 11.362$, df = 1, $p = 0.001$). Greater awareness was also observed among younger dental technicians, particularly those aged up to 34 years (70%) ($\chi 2 = 7.681$, df = 2, $p = 0.022$).

- ***Disinfection protocols***

Just over half of the respondents were aware of the required disinfection procedures. Statistically significant differences in awareness of the existence of a disinfection protocol in the laboratory were observed based on whether the respondent had participated in postgraduate infection control training ($\chi 2 = 14.537$, $p < 0.001$) (Table 2).

Table 2. Association between awareness of disinfection protocols and postgraduate IPC training

Infection Control Training	Disinfection Protocol Awareness		Total n (%)
	Unaware n (%)	Aware n (%)	
Within the last year	3 (25.0)	9 (75.0)	12 (100.0)
More than 1 year ago	3 (12.5)	21 (87.5)	24 (100.0)
No training received	85 (50.9)	82 (49.1)	167 (100.0)
Total	91 (44.8)	112 (55.2)	203 (100.0)

- ***Personal protective equipment (PPE) protocol***

Slightly over one-third (38.9%) of dental technicians were aware of the existence of a PPE protocol in the laboratory. The lowest awareness of the PPE protocols was observed among technicians who were not familiar with the concept of "cross-infection" (18%) ($\chi^2 = 12.433$, df = 1, $p = 0.000$) and those who had not completed postgraduate IPC training (34.7%) ($\chi^2 = 6.941$, df = 2, $p = 0.035$).

- ***Hand hygiene protocol***

Even fewer respondents were aware of the presence of a hand hygiene protocol at the workplace (30%). The data confirmed a trend of higher awareness among technicians who have completed postgraduate IPC training after graduation ($\chi^2 = 6.404$, df = 2, $p = 0.037$) and among those informed about the concept of "cross-infection" ($\chi^2 = 12.860$, df = 1, $p = 0.000$) (Table 3).

Table 3. Association between awareness of hand hygiene protocols and postgraduate IPC training

Infection Control Training	Hand Hygiene Protocol Awareness		Total n (%)
	Unaware n (%)	Aware n (%)	
Within the last year	7 (58,3)	5 (41,7)	12 (100,0)
More than 1 year ago	12 (50,0)	12 (50,0)	24 (100,0)
No training received	123 (73,7)	44 (26,3)	167 (100,0)
Total	142 (70,0)	61 (30,0)	203 (100,0)

Procedures for handling sharp objects, risk assessment protocols, and post-exposure policies - including first-aid procedures for needlestick or sharps injuries - are among the least familiar to dental technicians. Awareness of the existence of such protocols in laboratories ranges from only 9% to 20%. Those more likely to report awareness were typically younger technicians (≤34 years) and individuals who correctly defined the concept of cross-infection.

Attitudes toward Infection Control

- ***Self-assessment of occupational risk for cross-infection***

Nearly two-thirds of respondents perceived their own risk of cross-infection during work as either “high” (26.7%) or “moderate” (36.6%), while just over one-third (35.2%) assessed their individual risk as “low”. Only three respondents (1.5%) believed that no such risk existed.

Risk perception varied significantly by professional role within the laboratory ($\chi^2 = 12.842$, df = 3, $p = 0.004$). Employees consistently rated their risk as “high” (30.1%) or “moderate” (40.6%) compared to laboratory managers who reported lower rates (20.3% and 29%, respectively). None of the employees perceived the risk as non-existent. Dental technicians who reported “always” disinfecting materials with an unmarked disinfection status were most likely to rate their occupational risk as “low” or believe it was “non-existent” (41.3%). In contrast, those not practicing routine disinfection of materials more frequently assessed their risk as “high” (42.1%) ($\chi^2 = 13.209$, df = 4, $p = 0.010$).

Significant differences in risk self-assessment were further observed according to respondents’ age ($\chi^2 = 18.845$, df = 6, $p = 0.003$) and the

geographic location of the laboratory ($\chi^2 = 10.100$, df = 3, $p = 0.035$). Dental technicians aged ≤34 years more frequently defined their individual risk as "high" (34.4%) compared to those over 50 years of age (19.0%). Furthermore, technicians working in small towns or rural areas were substantially more likely to perceive their occupational infection risk as "non-existent" (14.3%) compared to those working in the capital or major regional cities (1.1%).

- ***Assessment of infection control measures in the workplace***

The majority of respondents (59.4%) rated the implementation of infection prevention and control (IPC) measures in their workplace as "very good" or "excellent" (Figure 3). Low implementation ratings were reported by only 10.4% of participants.

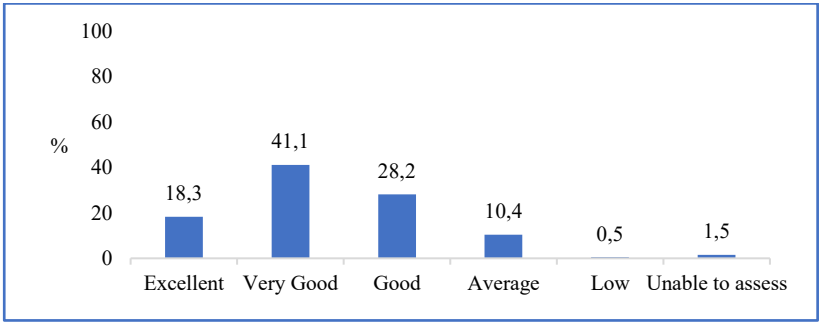

Figure 3. Assessment of the implementation of IPC measures in the laboratory

A clear pattern emerged linking the assessment of infection control (IC) measures to dental impression disinfection practices. Respondents who followed the full disinfection protocol for dental impressions were most likely to rate the implementation of IPC measures in their laboratories as "excellent" or "very good" (69.2%) ($\chi^2 = 26.473$, df = 6, $p < 0.000$).

Conversely, among participants who provided lower ratings ("average" or "low"), the largest proportion consisted of those who followed the disinfection protocol only partially (12.3%).

Statistically significant differences were also identified between the self-assessed implementation of IPC measures and the presence of a dedicated receiving and disinfection area within the laboratory ($\chi^2 = 21.109$,

df = 3, $p < 0.000$). Practitioners working in laboratories with a dedicated receiving area to contain and disinfect materials rated the implementation of IPC measures as "excellent" or "very good" in 71.8% of cases, compared to only 39.7% in laboratories without such areas.

The self-assessment of occupational infection risk was also found to have a significant influence on the evaluation of implemented infection control measures ($\chi^2 = 30.966$, df = 6, $p < 0.000$) (Table 4).

Table 4. Association between assessment of IPC measures implementation and occupational infection risk self-assessment

Self-Assessed Risk	Assessment of the implementation of infection control measures in the laboratory				Total n (%)
	Excellent/ Very good n (%)	Good n (%)	Average/ Low n (%)	Unable to assess n (%)	
High risk	28 (51.9)	19 (35.2)	7 (13.0)	0 (0.0)	54 (100.0)
Moderate risk	32 (43.8)	28 (38.4)	13 (17.8)	0 (0.0)	73 (100.0)
Low/Non-existent risk	59 (79.7)	10 (13.5)	2 (2.7)	3 (4.1)	74 (100.0)
Total	119 (59.2)	57 (28.4)	22 (10.9)	3 (1.5)	201 (100.0)

Respondents who perceived their occupational infection risk as "low" or believed it to be "non-existent" were substantially more likely to rate the implementation of IPC measures as "excellent" or "very good" (79.7%), whereas only a small fraction of this group (2.7%) rated implementation as "moderate" or "low".

This pattern was mirrored in the association between the awareness of IPC measures and the evaluation of their implementation in the laboratory ($\chi^2 = 34.909$, df = 6, $p < 0.001$). Respondents who rated their own level of awareness regarding IPC measures as "excellent" or "very good" predominantly evaluated the implementation of IPC measures at the same higher level (73.6%).

- ***Assessment of the financial burden of infection prevention and control measures***

Slightly more than one quarter of respondents (27.6%) perceived the financial burden associated with implementing infection prevention and

control measures as a significant constraint on the laboratory budget, while a comparable proportion (29.6%) did not consider it a barrier. Another 30% occupied a middle stance, finding the statement only partially true. The proportion of respondents who were unable to provide an opinion was 12.8%.

Dental technicians working in larger facilities (laboratories employing more than five technicians) were significantly more likely to consider infection prevention and control measures as constituting a substantial financial burden (33.3%) (χ^2 = 15.954, df = 3, p = 0.001). A comparable pattern was identified among respondents with more than 10 years of professional experience (χ^2 = 14.597, df = 3, p = 0.002), who also perceived IPC measures to be a major financial burden for the laboratory budget.

- ***Attitudes toward periodic IPC training***

The overall disposition of respondents toward periodic infection prevention and control training was decidedly positive. A substantial majority of participants (79.3%) explicitly approved the introduction of such training programmes.

A statistically significant association was identified between the perceived necessity of introducing postgraduate infection control training and the respondents' professional role within the laboratory (χ^2 = 13.724, df = 2, p = 0.001). Dental technicians under employment demonstrated markedly higher approval rates (86.5%) compared to laboratory managers (65.7%). Respondents working in larger facilities (laboratories employing more than six dental technicians) were significantly more likely to endorse the need for periodic infection control training (82.1%) compared to those working in smaller practices (up to three dental technicians) (67.9%) (χ^2 = 15.584, df = 4, p = 0.003).

Infection Control Practices

- ***Practices for handling non-disinfected dental impressions***

To evaluate impression disinfection practices, respondents were asked to describe their approach to handling dental impressions that had not undergone disinfection in the dental office prior to receipt in the laboratory.

Slightly more than one quarter of dental technicians (26.1%) reported consistently performing all required steps for proper disinfection of dental impressions. Of particular concern is the substantial proportion of respondents who treated contaminated impressions exclusively by rinsing with water (17.7%), while more than half (56.3%) reported only partial adherence to the disinfection protocol.

Statistically significant differences in impression disinfection practices were observed based on age and professional role within the laboratory. Dental technicians over 50 years of age most frequently reported compliance with the full disinfection protocol (28.6%), the majority of whom were employees (42.9%).

Notably, among laboratory managers, younger respondents, aged 34 and under, demonstrated the strongest compliance, reporting consistent performance of all required disinfection steps (66.7%), with none resorting to inadequate practices (i.e., rinsing with water only). Conversely, non-compliant disinfection practices were concentrated among employees aged 35-49 years.

Impression disinfection practices were also significantly associated with participation in postgraduate IPC training ($\chi^2 = 12.115$, df = 4, $p = 0.017$). Inadequate disinfection practices (rinsing with water only) were reported by 17.7% (n = 203) of dental technicians, all of whom lacked postgraduate IPC training.

Among dental technicians who consistently applied all steps of the disinfection protocol, the largest proportion consisted of those who had completed IPC training within the previous year (41.7%).

A similar statistically significant association was observed with respect to respondents' awareness of cross-infection ($\chi^2 = 12.403$, df = 2, $p = 0.002$). Among technicians who applied the full disinfection protocol, the largest proportion (31.6%) demonstrated high awareness of cross-infection hazards.

- ***Disinfection practices for incoming materials with an unmarked disinfection status***

Less than two-thirds of respondents (62.6%) confirmed routinely disinfecting materials arriving without clear disinfection status markings. For 28.1% of the participants, disinfecting such materials did not constitute a routine practice, with this cohort stating they performed the procedure only

"sometimes", whereas 9.4% reported not performing disinfection at all in these cases.

Significant differences were identified across the studied groups based on professional role ($\chi^2 = 6.892$, df = 2, $p = 0.032$) and size of the dental laboratory ($\chi^2 = 13.578$, df = 4, $p = 0.009$) (Table 5).

Table 5. Association between disinfection of materials with an unmarked status and size of the dental laboratory

Laboratory Size	Disinfection Practices for Incoming Materials			Total n (%)
	Always (Yes) n (%)	Sometimes n (%)	No n (%)	
≤ 2 technicians	56 (69.1)	13 (16.0)	12 (14.8)	81 (100.0)
3 to 5 dental technicians	47 (60.3)	26 (33.3)	5 (6.4)	78 (100.0)
> 6 dental technicians	20 (51.3)	17 (43.6)	2 (5.1)	39 (100.0)
Total n (%)	123 (62.1)	56 (28.3)	19 (9.6)	198 (100.0)

Dental technicians in managerial positions demonstrated higher compliance, reporting routine disinfection of unmarked materials (70.0%) more frequently than staff employees (58.6%). Technicians in small facilities were more than twice as likely to report never performing disinfection (14.8%) compared to those in medium-sized (6.4%) or large (5.1%) practices.

Additional characteristics influencing disinfection practices included sex ($\chi^2 = 8.057$, df = 2, $p = 0.018$) and age ($\chi^2 = 15.106$, df = 4, $p = 0.004$). Female respondents more frequently reported not disinfecting materials (15.2%) compared to their male counterparts (3.8%). Similarly, dental technicians aged over 50 years more commonly reported not performing disinfection (21.4%) compared to participants aged 34 or under (2.2%).

- ***Disinfection practices for outgoing materials prior to dispatch to dental offices***

More than one third of dental technicians (37.4%) confirmed disinfecting materials prior to dispatch to the dental office, while 10.3% indicated that they performed disinfection only "sometimes." Of particular note, a concerning majority (52.2%) reported that they never routinely disinfect materials prior to dispatch.

Dental technicians aged 35-49 years demonstrated particularly low compliance, with 71.75% reporting no pre-dispatch disinfection ($\chi^2 = 14.528$, df = 4, $p = 0.006$) (Table 6).

Table 6. Association between pre-dispatch disinfection practices and age groups

Age Group	Disinfection Prior to Dispatch to the Dental Office			Total n (%)
	Always (Yes) n (%)	Sometimes n (%)	No n (%)	
Up to 34 years	41 (45,6)	10 (11,1)	39 (43,3)	90 (100,0)
35 to 49 years	15 (25,0)	2 (3,3)	43 (71,7)	60 (100,0)
Over 50 years	14 (33,3)	7 (16,7)	21 (50,0)	42 (100,0)
Total	70 (36,5)	19 (9,9)	103 (53,6)	192 (100,0)

- ***Disinfection practices for denture polishing materials***

More than half of the dental technicians (55.9%) reported never adding disinfectant to pumice slurry during polishing procedures. Only 4.5% confirmed practicing this routinely, and an equal proportion reported doing so "sometimes."

Among respondents who routinely added disinfectant to the pumice slurry, the highest compliance was observed in technicians over 50 (9.5%) and those with over 10 years of professional experience (5.6%) ($\chi2 = 15.215$, df = 3, $p = 0.002$ for both).

- ***Presence of a designated receiving and disinfection area within the laboratory***

Fewer than two thirds (61.6%) of the respondents reported that their laboratory had a designated receiving area to contain and disinfect materials, in accordance with CDC recommendations.

No statistically significant differences were identified regarding the presence of a designated receiving and disinfection area within the laboratory when analysed by professional role, laboratory size, or laboratory location. Nevertheless, the proportion of large laboratories with such a designated area (66.7%) was higher than that of smaller laboratories (59.1%).

- ***Use of personal protective equipment (PPE)***

The majority of respondents (74.9%) reported using protective clothing while working. However, nearly 40.0% of participants did not use gloves, 36.5% did not use protective eyewear or face shields, and 56.2% did not use masks. Only seven dental technicians (3.4%) reported using none of the listed personal protective equipment (PPE) during routine activities. Age significantly influenced PPE use patterns ($\chi^2 = 28.715$, df = 8, $p < 0.001$) (Table 7).

Table 7. Association between PPE usage levels and age groups

Age Group	Use of Personal Protective Equipment (PPE)					Total n (%)
	No PPE n (%)	One PPE item n (%)	Two PPE items n (%)	Three PPE items n (%)	Full PPE set n (%)	
Up to 34 years	3 (3.3)	7 (7.8)	28 (31.1)	26 (28.9)	26 (28.9)	90 (100.0)
35 to 49 years	4 (6.7)	12 (20.0)	23 (38.3)	14 (23.3)	7 (11.7)	60 (100.0)
Over 50 years	1 (2.4)	16 (38.1)	4 (9.5)	11 (26.2)	10 (23.8)	42 (100.0)
Up to 34 years	8 (4.2)	35 (18.2)	55 (28.6)	51 (26.6)	43 (22.4)	192 (100.0)

Only about one-fifth of technicians (22.4%) reported using the full set of recommended PPE, a practice most common among the youngest age group (≤34 years). In contrast, dental technicians aged over 50 years demonstrated lower levels of PPE compliance, most frequently reporting the use of only one of the listed protective items (38.1%).

- ***Hand hygiene***

The results indicate that hand hygiene is most commonly performed when hands are visibly soiled (77.8%). It is noteworthy that one in four respondents reported not performing hand hygiene after contact with materials potentially contaminated with blood, saliva, or respiratory secretions (Figure 4).

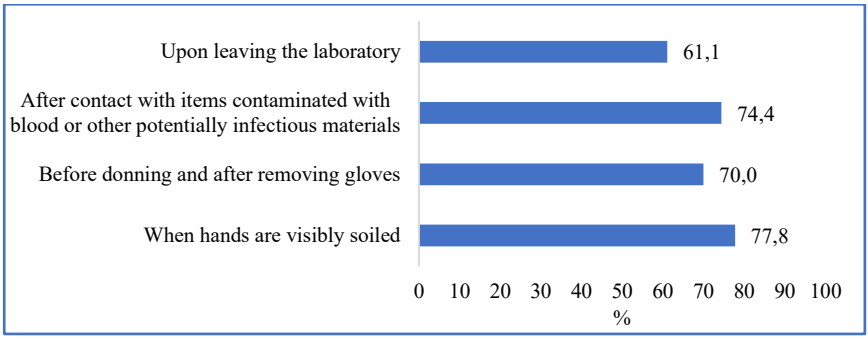

Figure 4. Frequency of hand hygiene practices

Statistically significant differences were identified based on age ($\chi 2$ = 8.657, df = 2, p = 0.014). Younger technicians (up to 34 years) demonstrated higher compliance when hands were visibly soiled (87.8%) compared to those over 50 years of age.

Length of professional experience ($\chi 2$ = 5.133, df =1, p = 0.025), professional role ($\chi 2$ = 7.076, df =1, p = 0.012), and laboratory size ($\chi 2$ = 6.462, df = 2, p = 0.039) also significantly influenced reported hand hygiene practices.

Staff employees demonstrated higher compliance (83.5%) compared to laboratory managers (67.1%). This practice was also more prevalent among participants with less professional experience.

The same age- and experience-related gradient was observed regarding hand hygiene before donning and after removing gloves. Technicians up to 34 years of age confirmed this practice more frequently (46.7%) than those over 50 (28.6%; $\chi 2$ = 13.576, df = 2, p = 0.001). Furthermore, the proportion of respondents with up to 10 years of experience who performed hand hygiene before and after glove use (48.9%) was approximately twice as high as that of technicians with over 10 years of experience (22.2%; $\chi 2$ = 15.482, df = 1, $p < 0.000$).

- ***Frequency of sharps and needlestick injuries***

Sharps and needlestick injuries during work were reported by almost all respondents (92.6%). Among them, nearly two-thirds (62.1%) described such incidents as occurring rarely, while 30.5% reported frequent occurrence.

The respondents who most frequently experienced occupational injuries were in the up to 34 age group (47.8%; $\chi 2 = 31.400$, df = 4, $p < 0.000$) and those with up to 10 years of experience (47.8%; $\chi 2 = 23.839$, df = 2, $p < 0.000$). Technicians over 50 years of age (88.1%) and those with over 10 years of experience (76.9%) most often reported such incidents as rare.

- ***Hepatitis B vaccination coverage***

Fewer than half of the respondents (43.8%) reported being vaccinated against the Hepatitis B virus (HBV). Uptake was significantly higher among younger technicians aged 34 and under, while 64.3% of those aged over 50 had not been vaccinated ($\chi^2 = 14.093$, d f= 2, $p = 0.001$). Neither sex nor participation in postgraduate infection control training appeared to influence vaccination status significantly ($p = 0.500$ and $p = 0.423$, respectively).

Communication between dental laboratories and dental offices

- ***Methods of communication regarding the disinfection status of incoming materials***

Respondents were asked to specify how they were informed about the disinfection status of materials coming from dental offices to the laboratory.

Nearly half (48.5%) reported that their laboratory received no information about whether materials had been disinfected prior to arrival. Where such information was conveyed, only 17.5% of dental technicians reported receiving written confirmation in the form of a label affixed to the packaging, while 34.0% indicated that the information was communicated verbally.

Although differences according to laboratory size were not statistically significant ($\chi^2 = 4.513$, df = 4, $p = 0.341$), it is worth noting that technicians working in large laboratories (33.3%) were considerably less likely to report a total absence of information compared to those working in medium-sized settings (50.9%)

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- ***Methods of communication regarding the disinfection status of outgoing materials***

More than half of the respondents (51.5%) reported that their laboratory did not routinely provide any information regarding the disinfection status of materials dispatched from the laboratory to dental offices. Only 12.5% reported placing a label containing the relevant information on the packaging, while 36.9% relied solely on verbal communication.

No statistically significant associations were identified with respect to laboratory size or professional role. Nevertheless, employed staff members and technicians working in larger laboratories (with more than six employees) more frequently confirmed using labelling as a method of communication.

- ***Type of packaging of incoming materials***

Regarding the methods employed for the packaging of incoming materials received from dental offices, tightly sealed plastic bags constituted the most frequently reported method, identified by 82.0% of respondents, while roughly one in five (21.2%) indicated the use of tightly sealed containers as an alternative.

Of concern, 22.0% of respondents reported receiving materials wrapped in disinfectant-soaked paper towels - an improper packaging method that may facilitate microbial contamination and undermine infection control standards. This practice was reported significantly more often by technicians in larger laboratories (over six employees) (41.0%) compared to only 16.4% of those in smaller facilities ($\chi^2 = 11.408$, df = 1, $p = 0.001$).

- ***Type of packaging of outgoing materials***

The most common packaging method for outgoing materials, confirmed in 86.7% of cases, was a tightly sealed plastic bag. Sealed containers were used less frequently, as reported by 27.6% of respondents. Only 5.4% of technicians reported dispatching materials improperly wrapped in disinfectant-soaked paper towels.

No statistically significant differences were found in dispatch packaging methods with regard to practice size, professional role, or

geographical location. Notably, laboratories located in small settlements reported no instances of dispatching improperly packaged materials.

Factors influencing dental technicians' infection prevention and control practices

To assess the overall level of adherence to recommended infection prevention and control guidelines, a composite scoring approach was applied:

- One point was awarded for each recommended standard IPC measure reported as implemented by the respondent;
- A summary variable was then constructed with a maximum possible score of 18 points, representing the total number of mandatory IPC elements implemented by each participant.
- A three-level scale was created to categorize infection prevention and control practices: Low (0–6 points), Moderate (7–13 points), and Good (14–18 points), enabling an overall evaluation of each participant's IPC performance.

The maximum score achieved was 16 points, obtained by a single respondent. Only 22 participants (10.8%) achieved a score of 13 or higher, which was defined as the threshold for adequate compliance with infection prevention and control measures.

In the first stage, a univariate regression analysis was conducted to examine associations between compliance levels and the following potential predictors:

- Demographic factors: sex, age, length of professional experience, laboratory size, and geographic location;
- Awareness-related factors: self-assessed knowledge level, correct definition of cross-infection, awareness of workplace IPC protocols, and prior infection control training;
- Attitude-related factors: perceived personal cross-infection risk, attitudes toward periodic infection prevention and control training, perceived financial burden of implementing IPC measures, and perceived level of implementation of cross-infection control measures in the workplace.

In the second stage, a multiple regression analysis was performed using two models. Model 1 included variables showing significant correlation in the univariate analysis, namely, level of awareness, age, and self-assessed

level of implemented cross-infection control measures. This model significantly predicted the level of IPC practice, $F(3, 184) = 21.59$, $p < 0.001$, explaining 26.0% of the variance ($R^2 = 0.260$; adjusted $R^2 = 0.248$).

Model 2 incorporated two dummy variables derived from responses to the question assessing the definition of cross-infection with incorrect responses coded as 1. This addition significantly improved the model, $F(5, 182) = 16.83$, $p < 0.001$, with the coefficient of determination reaching $R^2 = 0.316$ (adjusted $R^2 = 0.297$).

In this final model, self-assessed level of implementation of cross-infection control measures emerged as the strongest predictor of actual compliance ($\beta = -0.295$, $p < 0.001$), followed by age ($\beta = -0.264$, $p < 0.001$) and level of cross-infection awareness ($\beta = -0.166$, $p = 0.016$). Participants who selected incorrect definitions of cross-infection (categories 1 and 2) demonstrated significantly lower IPC practice scores ($\beta = -0.159$, $p = 0.014$; $\beta = -0.204$, $p = 0.001$, respectively).

4. Results of the study on disinfection and communication practices among dental practitioners regarding infection prevention and control in the dental laboratory

The final sample comprised 205 dental practitioners. The socio-demographic characteristics of the respondents are presented in Table 8.

Table 8. Socio-demographic characteristics of study population

Characteristics	**n (%)**
Sex	
Women	106 (51.5)
Men	99 (48.5)
Age (years), median (IQR)	37 (18.0)
Clinical experience (years), median (IQR)	12.5 (18.0)
Geographic location of the Dental Practice	
Capital / Regional center	165 (81.7)
Small town	25 (12.4)
Village	12 (5.9)
Dental Practice Size	
Small (1–2 dentists)	121 (60.5)
Medium (3–5 dentists)	53 (26.5)
Large (over 6 dentists)	26 (13.0)

The participants were evenly distributed by sex. The mean age was 37 years, and the average professional experience exceeded 12 years. The majority of respondents (60.5%) worked in practices with up to two dentists, primarily located in the capital or major regional cities, while nearly one quarter practiced in small towns or rural areas.

No statistically significant differences were identified between male and female respondents with respect to age ($t = -1.15$, $p = 0.253$) or length of professional experience ($t = -1.32$, $p = 0.189$).

- ***Self-assessment of dental practitioners' awareness of infection prevention and control***

More than two thirds of the participants (76.6%) rated their IPC awareness as "very good" or "excellent", while approximately one quarter (22.5%) assessed their level of awareness as "moderate" or "good."

When analysed by age, a correlation was identified between self-assessed IPC knowledge and age ($\chi^2 = 13.640$, df = 6, $p = 0.034$). Among those who rated their awareness as "excellent" or "very good," the largest proportion consisted of younger dentists up to 34 years of age (39.2%). Conversely, practitioners over 50 years of age were the most likely to provide a "moderate" or "low" self-assessment (22.7%).

A significant difference was also established with respect to length of professional experience ($\chi^2 = 16.659$, df = 6, $p = 0.010$). Respondents with fewer years of experience were more likely to report higher self-assessed knowledge, whereas dentists with more extensive professional experience were more inclined to rate their IPC awareness as "low."

Geographic location was similarly associated with self-assessed awareness ($\chi^2 = 14.815$, df = 6, $p = 0.022$). Practitioners practicing in the capital or major regional cities more frequently rated their awareness as "excellent" (35.8%) or "very good" (42.4%) compared to those practicing in rural areas (25.0% and 8.3%, respectively). The highest proportion of respondents who rated their awareness as "low" were dentists working in rural settings (33.3%).

Communication between dental offices and dental laboratories

- ***Methods of communication regarding the disinfection status of incoming materials***

Less than one-third of the dentists (31.2%) reported receiving information about the disinfection status of materials incoming from dental laboratories via a label affixed to the packaging (31.2%). A comparable proportion (32.7%) indicated that the information was communicated verbally.

Of particular note, more than one third of respondents (35.1%) reported receiving no information about disinfection status from the laboratory. Only two participants (1.0%) indicated adherence to a formal, agreed-upon inter-institutional disinfection protocol, whereby all incoming materials were routinely disinfected upon receipt.

A statistically significant association was demonstrated between the method of communication and age groups ($\chi^2 = 20.024$, df = 4, $p < 0.001$) (Figure 5).

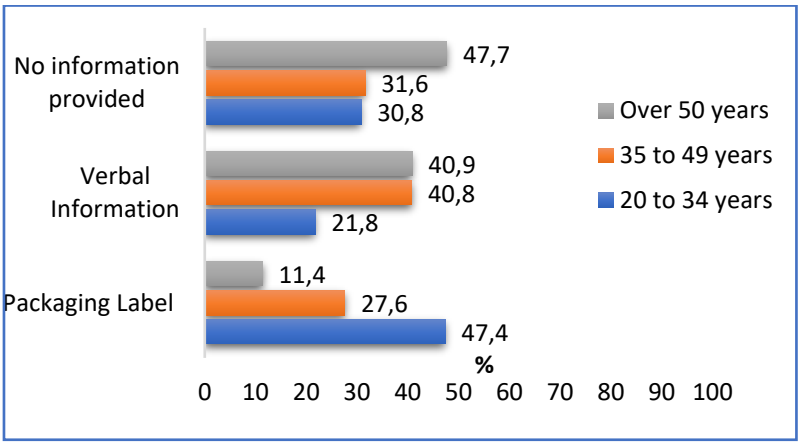

Figure 5. Association between methods of communication and age groups

Among the age groups, dentists up to 34 years old most frequently reported being informed via packaging labels (47.4%). Of those who reported receiving no information, the largest proportion were practitioners over 50

years of age (47.7%). This same age group also relied most heavily on verbal communication (40.9%).

- ***Methods of communication regarding the disinfection status of outgoing materials***

With regard to the methods employed to communicate disinfection status of materials dispatched to dental laboratories, verbal communication was identified as the predominant practice, adopted by 41.0% of respondents. Slightly more than one quarter of respondents (26.8%) reported that they place a label on the packaging indicating the disinfection status.

Of particular note, however, is that nearly one third of respondents (31.7%) did not communicate disinfection information to the laboratory by any means, while only a single respondent (0.5%) indicated adherence to a formal, agreed-upon inter-institutional disinfection protocol, whereby outgoing materials were consistently disinfected at the dental office prior to their dispatch to the laboratory.

Statistically significant variation in communication practices was demonstrated across professional experience categories ($\chi^2 = 22.502$, df = 6, $p < 0.001$). Less experienced practitioners (up to 9 years of professional experience) were more likely to use labels (42.2%), while those with over 20 years of experience were most likely not to communicate disinfection status at all (45.9%) ($\chi^2 = 22.502$, df = 6, $p = 0.000$).

- ***Disinfection practices for outgoing materials prior to dispatch to dental laboratories***

Fewer than half of the surveyed dental practitioners (47.5%) confirmed that they perform disinfection on clinical materials before sending them to the dental laboratory. Equal proportions of participants reported that they either do not perform disinfection at all (26.5%) or do so only "sometimes" (26.0%).

Significant differences in disinfection practices were observed according to age ($\chi2 = 15.039$, df = 4, $p = 0.004$) and length of professional experience ($\chi2 = 25.186$, df = 4, $p<0.001$). Dentists with up to 9 years of experience (65.9%) and younger practitioners (up to 34 years of age; 62.8%) most frequently reported that they “always” disinfect materials prior to dispatch to the dental laboratory. Among respondents who reported not performing disinfection, the highest relative shares were observed among

older practitioners over 50 years of age (38.6%) and those with the longest professional experience (42.6%).

- ***Disinfection practices for incoming materials with an unmarked disinfection status received from dental laboratories***

Fewer than half of the respondents (40.2%) reported that they routinely disinfect materials with an unmarked disinfection status received from the dental laboratory. An unacceptably high proportion of dentists confirmed that they either did not disinfect the incoming materials (30.4%) or apply this practice only "sometimes" (29.4%).

Significant differences were observed in disinfection practices for incoming materials with an unmarked disinfection status based on length of professional experience ($\chi^2 = 14.942$, df = 4, $p = 0.005$) (Figure 6).

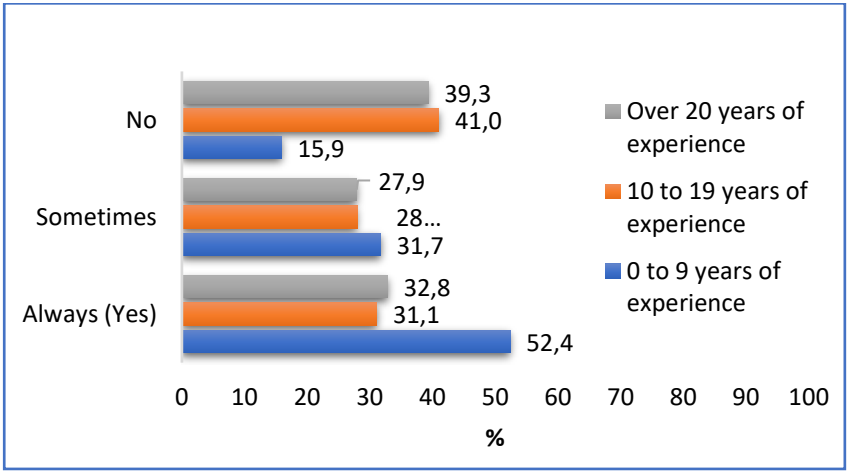

Figure 6. Association between disinfection practices for materials with an unmarked disinfection status and length of professional experience.

Dentists with fewer years of professional experience (up to 9 years) most frequently confirmed that they "always" disinfect materials received from the laboratory (52.4%). Within the group with the longest professional

experience (over 20 years), the largest proportion consisted of those who did not disinfect the materials (39.3%).

Among all compared groups, practitioners in small towns most frequently confirmed a consistent practice of “always” disinfecting incoming materials (48.0%), followed by those practicing in the capital or major regional cities (39.0%) ($\chi^2 = 9.721$, df = 4, $p = 0.042$). The practice of not disinfecting materials received from the laboratory was most prevalent in rural settings (66.7%). No statistically significant differences were identified with respect to respondents’ sex ($p = 0.849$) or age ($p = 0.062$).

- ***Methods of packaging outgoing materials upon dispatch to dental laboratories***

Regarding the methods employed for the packaging of dental impressions, prosthetic constructions, and other clinical materials dispatched from the dental office to the laboratory, tightly sealed plastic bags constituted the most frequently reported method, identified by 75.1% of respondents. A significantly smaller proportion (31.7%) indicated the use of tightly sealed containers. Of concern, in 12.2% of cases, outgoing materials were improperly packaged in disinfectant-soaked paper towels.

Statistically significant variation in packaging practices was demonstrated across professional experience categories ($\chi2 = 13.102$, df = 2, $p = 0.001$).

Packaging in tightly sealed plastic bags was most prevalent among practitioners with 10 to 19 years of experience (85.2%). Among those utilizing rigid containers, the largest share consisted of dental practitioners with up to 9 years of professional experience (45.8%).

Respondents were also asked to specify how they receive materials back from their partnering dental laboratories. The majority (79.0%) reported receiving materials in tightly sealed plastic bags. The share reporting a sealed container was two and a half times lower (31.2%), while only 2.0% reported receiving materials improperly wrapped in disinfectant-soaked paper towels. Three respondents (1.5%) indicated yet another method involving paper towels moistened with a small amount of water.

Consistent with the findings for outgoing materials, packaging practices for incoming items were significantly influenced by the length of professional experience. Respondents with over 10 years of professional experience (90.2%) more frequently confirmed receiving materials in plastic

bags ($\chi 2 = 8.817$, df = 2, $p = 0.012$), whereas dental practitioners with less professional experience (up to 9 years) more often indicated receiving materials in a "sealed container" (44.6%).

- ***Presence of a designated infection control coordinator within the dental office***

While creating and maintaining a safe working environment requires the commitment of all healthcare professionals, an infection control coordinator is specifically responsible for overseeing the infection prevention and control (IPC) programme within a healthcare facility. Nearly two-thirds of participants (61.8%) reported the absence of such a designated staff member in their dental facility, while 18.6% were unsure. Fewer than one fifth (18.6%) of respondents worked in dental offices that employ a designated person responsible for infection prevention and control, with this frequency being statistically significantly higher among dental practitioners aged up to 34 years ($\chi^2 = 22.996$, df = 4, $p = 0.000$), and consequently among those with up to 9 years of professional experience ($\chi^2 = 16.331$, df = 4, $p = 0.002$).

5. Synthesis of findings across the four empirical studies

The historical evolution of infection prevention and control policies in dentistry reflects the dynamic interplay between scientific advancement, public health imperatives, and clinical practice. Internationally endorsed IPC guidelines for dental facilities have progressively developed over the years into a comprehensive standard of good practice that ensures the safety of patients and healthcare professionals alike.

Analysis of the regulatory framework related to infection prevention and control in Bulgaria indicates that while regulations exist for dental practices and dental laboratories, dental laboratory practice remains largely in the shadow of the regulations governing dental practitioners. IPC regulations concerning dental laboratories are scattered across various legislative documents. For example, the 2013 Medical Standard on the Prevention and Control of Healthcare-Associated Infections does not include the term “medical-technical laboratory.” Furthermore, while the activities of dental practitioners are addressed specifically and in detail, no parity has been established between the requirements applicable to dental practices and those applicable to dental laboratories.

To date, Bulgaria lacks national recommendations or guidelines for infection control in dental laboratories that would support professionals in complying with applicable standards and regulatory requirements.

While the Bulgarian Association of Dental Technicians is formally responsible for organizing and delivering continuing education for dental technicians, no such structured programmes have been established in practice, and infection control training remains entirely absent.

A growing body of international research has investigated the knowledge, attitudes, and practices surrounding infection prevention and control in dental laboratories, recognizing this domain as a critical determinant of safety for both patients and dental healthcare professionals. Findings across multiple independent studies converge on a common concern: substantial deficiencies in dental technicians' awareness of IPC protocols and practices that do not comply with established guidelines.

Findings from studies on the knowledge, attitudes, and practices of Bulgarian dental technicians concerning cross-infection control point to systemic and educational shortcomings in laboratory infection prevention and control. The research has identified significant deficiencies in key areas, including adherence to disinfection protocols, proper use of personal protective equipment, hand hygiene compliance, communication between laboratories and dental offices, and hepatitis B virus (HBV) vaccination. These results underscore the critical need for on-going professional education, the implementation of mandatory written protocols, and enhanced regulatory oversight to safeguard occupational health and patient welfare. Future work should be directed toward creating and testing targeted interventions to effectively bridge the gap between knowledge and practice for this key group of healthcare professionals.

The evaluation of dentists’ disinfection protocols and communication habits relevant to infection prevention and control in dental laboratories has revealed systemic failures in the decontamination of materials moving between dental offices and laboratories. Crucially, the communication link between these two healthcare settings is not organized or coordinated to a standard that ensures procedural safety.

The results obtained largely corroborate the initial research hypotheses. Analysis of the regulatory framework, together with data from surveys of dental technicians and dentists, confirms the hypothesis positing a

lack of targeted national infection prevention and control recommendations and guidelines for dental laboratories. The identified shortcomings in information dissemination, limited post-graduate training, and poor awareness of existing written protocols within laboratories all support the hypothesis that professionals lack sufficient knowledge resources and structural support.

The research provides partial confirmation for the hypothesis addressing the discord between perceived infection risk and actual practice. Evidence indicates that while dental professionals rate their own knowledge highly and hold positive views on infection prevention and control, their routine professional practices often fail to comply with international standards. This theory-practice gap manifests most clearly across three domains: disinfection procedures, adherence to personal protective equipment protocols, and hand hygiene practices.

The evidence strongly supports the hypothesis that critical IPC practices are implemented at unsatisfactory levels and that inter-facility communication between dental practices and dental laboratories remains insufficiently effective. These identified shortcomings underscore the need for professionally organized educational interventions, the development of clear written protocols, and strengthened regulatory oversight, which further confirms the final research hypothesis that targeted initiatives are required to improve both awareness and practices within this domain.

6. Proposed framework for infection prevention and control training within the dental laboratory

Reflecting on a literature review spanning 23 years of infection prevention and control in dental laboratories, the findings from our empirical studies indicate that dental technicians' practices in managing biological hazards are not yet optimal and require further improvement.

In accordance with the Bulgarian national regulatory framework, the proposed training model (Figure 7) is grounded in the legislation of the Republic of Bulgaria - specifically Ordinance No. 3 (8 May 2013) on the Medical Standard for the Prevention and Control of Healthcare-Associated Infections, and Ordinance No. 4 on the protection of workers from risks related to exposure to biological agents at work. These regulations mandate that employers provide employees with structured and appropriate training.

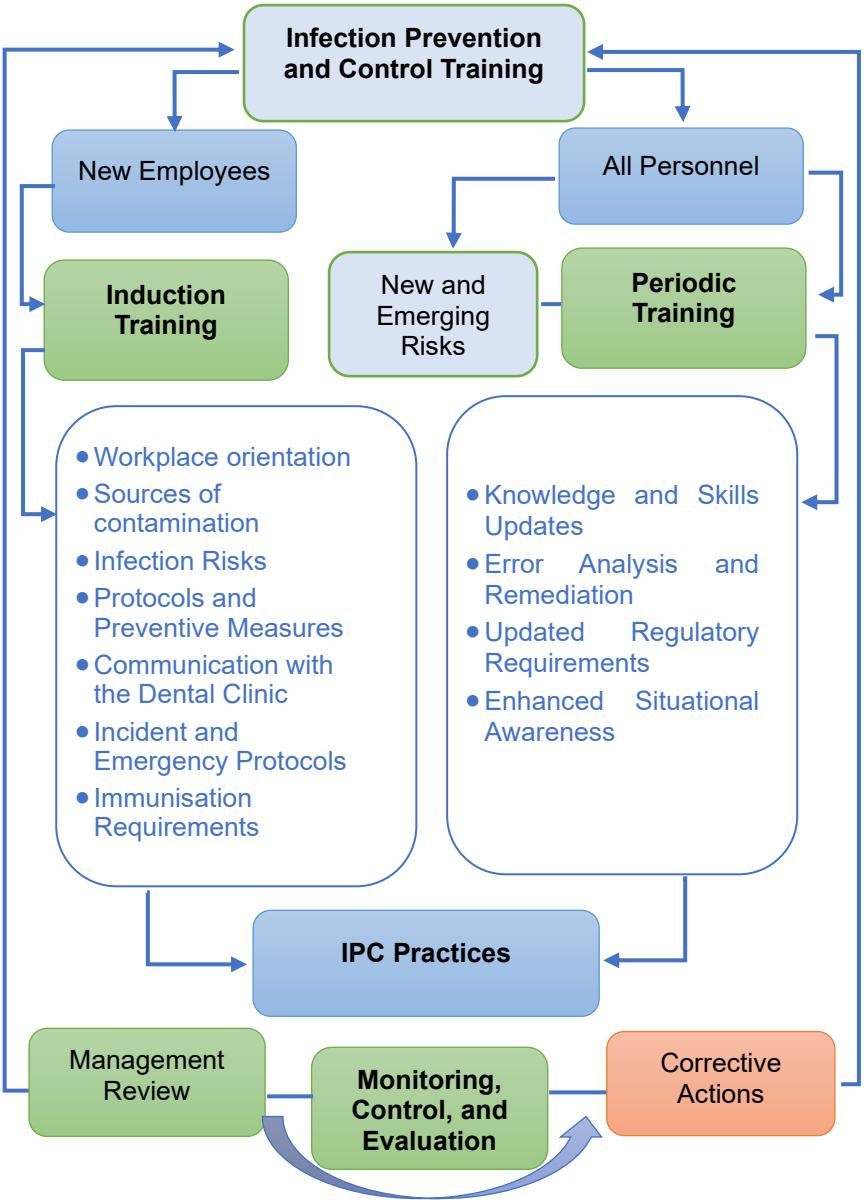

Figure7. Organization of IPC training

As stipulated by Ordinance No. 4, training must be provided: (1) upon commencement of employment, in the form of induction training; (2) in response to new or emerging risks; and (3) on a recurring, periodic basis.

Infection prevention and control training should be tailored to the specific duties and responsibilities of dental technicians, drawing on relevant policies, guidelines, regulations, and professional standards. For such training to be effective, the laboratory must develop clearly defined Standard Operating Procedures (SOPs) for infection prevention and control, addressing each stage of the workflow and providing explicit guidance on their application.

Training should combine both theoretical and practical components and delivered in individual or group settings. A range of instructional methods may be employed, including briefings, demonstrations, seminars, practical exercises, and multimedia formats.

Monitoring and evaluation of training outcomes should be conducted using appropriate assessment tools, such as procedural checklists and periodic audits of infection prevention and control practices.

All staff must complete comprehensive training in the laboratory's infection prevention and control procedures prior to commencing work, as they are expected to be familiar with and adhere to these procedures in their day-to-day practice. Periodic training is essential to ensure that applied practices remain aligned with current IPC requirements and to identify and address any gaps or errors.

Responsibility for induction training rests with the Laboratory Manager, or a suitably qualified individual appointed for this purpose. To enhance the effectiveness and technical rigour of periodic training, an interdisciplinary approach is recommended, drawing on the expertise of:

- Occupational Health Services (OHS): For workplace-specific hazard identification and risk assessment.
- Regional Health Inspectorates (RHI): For epidemiological expertise and regulatory health oversight.
- The Bulgarian Association of Dental Technicians: For access to external subject matter experts and guest lecturers.

CONCLUSIONS

1. A review of the scientific literature shows that infection prevention and control (IPC) in dental laboratories remains an insufficiently researched area in Bulgaria, despite a growing body of international publications on the subject.

2. An analysis of the Bulgarian regulatory framework related to infection prevention and control demonstrates that while existing legislation generally reflects internationally recognised standard measures applicable to dental practice, the specific features and operational requirements of dental laboratories are not regulated with the same depth and specificity as those found in the guidelines of other international organisations.

3. Survey results demonstrate a high level of self-reported awareness of workplace infection prevention and control among healthcare professionals, though significant variation exists between professional groups. Dentists were more likely to assess their knowledge as “very good” or “excellent” (76.6%) compared to dental technicians (54.8%).

4. Evaluation of theoretical knowledge shows that 75.2% of dental technicians correctly define cross-infection, suggesting a fundamental understanding of the concept.

5. Awareness of the existence of written infection prevention and control protocols in the workplace is limited among dental technicians, particularly regarding post-exposure prophylaxis (9.9%), sharps safety (19.7%), risk assessment (21.7%), and hand hygiene protocols (30%).

6. Postgraduate training in infection prevention and control after completion of formal education remains poorly represented within the profession. Fewer than one in five technicians reported participation in such training post-qualification, and only 5.9% had attended a course within the preceding year. These findings support the hypothesis that structured, professionally organised educational initiatives are needed.

7. Dental technicians demonstrate a proactive attitude toward infection prevention and control; nearly two-thirds (62.6%) perceive their occupational infection risk as moderate or high, and 79.3% believe that additional training is necessary.

8. The analysis of infection prevention and control practices in dental laboratories reveals substantial deficiencies, including inconsistent

disinfection of incoming material, non-compliance with or incorrect application of impression disinfection procedures, and the lack of a dedicated receiving/disinfection areas to contain and decontaminate materials; furthermore, there is inconsistent use of personal protective equipment (PPE), inadequate adherence to hand hygiene protocols, and low hepatitis B virus (HBV) vaccination coverage.

9. Inter-facility communication failures between dental clinics and laboratories appear to stem both from a mutual underestimation of infection prevention and control in collaborative workflows and the absence of clearly delineated responsibilities between the parties involved.

10. Materials with an unmarked disinfection status are often handled unsystematically, and their transfer from dental practices to dental laboratories and vice versa frequently occurs in unprotected packaging. These practices pose direct health risks to both dental professionals and patients.

11. Factors associated with good IPC practices include younger age, greater theoretical knowledge, and higher self-assessed IPC competence - all of which are directly linked to the implementation of effective and systematic training.

RECOMMENDATIONS

I. To the Legislative Authority:

1. The national regulatory framework governing infection prevention and control in dental practice should be revised and expanded to explicitly address the specific characteristics of dental laboratory activity.

1.1 In this context, dedicated infection prevention and control requirements tailored to dental laboratory practice should be developed and formally introduced.

2. The Ordinance on Uniform State Requirements should be amended in the section relating to the "Dental Technician" specialty. A standalone academic discipline focused on infection prevention and control in dental laboratories should be incorporated into the mandatory curriculum, thereby ensuring a unified national standard of education and training in this field.

II. To Professional Organisations (BgDA and BDAT):

1. A sustainable system for Continuing Professional Development (CPD) in infection prevention and control should be established and maintained for dental technicians at all stages of their professional careers. This system should include:

- Regularly organised courses, seminars, and online training programmes;
- Incentive mechanisms to stimulate participation, such as credit accumulation, certification, and formal linkage between training and professional advancement.

2. Practical tools should be developed to support the effective implementation of IPC standards in everyday practice. These should include best practice guidelines, visual materials (e.g., posters and algorithms), as well as standardised written protocols and instructional manuals.

3. Professional organisations should develop and submit for approval formal Codes of Practice establishing clear requirements for communication and coordination between dental laboratories and dental

practices. These should define the responsibilities of each party in relation to disinfection, and standardise procedures for the transfer and receipt of items with clearly designated disinfection status.

III. To the Ministry of Health and Regional Health Inspectorates (RHI):

1. Regulatory oversight of infection prevention and control practices in dental laboratories should be strengthened through:

- Systematic monitoring of the existence and practical implementation of written protocols;
- Monitoring the vaccination status of all laboratory personnel;
- The introduction of structured educational measures, delivered by certified IPC trainers in dental laboratories, when deficiencies are identified - rather than reliance solely on punitive sanctions.

SUMMARY

Infection prevention and control is a fundamental pillar of professional practice for all dental practitioners, including dental technicians.

The historical review of the international regulatory framework highlights key milestones in the codification of IPC within dentistry, particularly the rigorous focus on training and the continuous oversight of laboratory workflows. By contrast, this international benchmark exposes a significant neglect of training for dental technicians in Bulgaria. In practice, these professionals are left to navigate a fragmented regulatory landscape where the specific operational nuances of dental laboratories remain neither sufficiently addressed nor effectively regulated.

The identified educational gap is further substantiated by the findings of this original study, conducted across a representative sample of the Bulgarian professional community. The research examined knowledge, attitudes, and practices regarding cross-infection control, alongside their determining factors. The data reveals a series of systemic deficiencies and challenges, affecting both the level of awareness and the practical implementation of infection prevention and control measures among technicians.

Furthermore, an analysis of the communication and coordination between laboratories and clinics concerning material disinfection identifies critical shortcomings, which introduce avoidable health risks for both patients and staff.

Ultimately, these findings underscore an urgent need to enhance practitioner awareness, foster professional accountability, and embed sustainable infection prevention and control protocols. Minimising infection risks and cultivating a robust safety culture requires a concerted, long-term commitment from all stakeholders - professional bodies, regulators, the academic community, and dental practitioners alike.

SCIENTIFIC CONTRIBUTIONS

Theoretical and Conceptual Contributions:

1. An in-depth review and analysis of the historical development of international infection prevention and control guidelines, with a focus on dental laboratories.
2. A review of the Bulgarian national regulatory framework, identifying critical aspects of dental technology practice that are currently not adequately regulated.
3. The first nationwide, representative study conducted in Bulgaria on the knowledge, attitudes, and practices (KAP) of dental technicians regarding infection prevention and control.
4. An investigation into disinfection processes and communication between dental clinics and laboratories as key determinants of infection prevention and control effectiveness.
5. Identification of specific needs and problematic areas in laboratory practice, alongside opportunities for procedural optimisation.
6. A comprehensive analysis of results, enabling the formulation of recommendations for responsible institutions to improve infection prevention and control in dental laboratories and enhance postgraduate training for dental technicians.

Practical and Applied Contributions:

1. Development of a research toolkit informed by a scoping review of international methodologies dedicated to cross-infection control in dental laboratories;
2. A proposed framework for workplace infection prevention and control training, tailored specifically to the requirements and routines of dental laboratory practice.

PUBLICATIONS ASSOCIATED WITH THIS THESIS

1. Kalpakchieva N, Dokova K. Контрол на кръстосаните инфекции в зъботехническите лаборатории – обзор [Cross-infection control in dental laboratories: an overview]. *Varna Medical Forum*. 2023; 12(2): 159-167. doi: 10.14748/vmf.v12i2.9232
2. Kalpakchieva N, Dokova K. Guidelines and policies for infection control in dental laboratories. Scripta scientifica salutis publicae. 2025; 11: 13-22.