A Relational Database Model for Food Safety and Restaurant Inspection Data

Project Proposal

Group E

Team Members:
Azhar Serik
Aruzhan Oshakbayeva
Balazs Remenyi
Daryna Tkachenko

DNDS5020: Data Management and Databases
Instructor: Jascha Grübel

Food inspections are a key mechanism to maintain the safety standards of food and beverage establishments such as restaurants, cafés, and bars in order to protect public health. These establishments are inspected repeatedly by institutions, with outcomes ranging from minor remarks to serious violations that may trigger enforcement actions. Although the results of inspections are often available on open data portals, they are typically represented in a simplified form. This means that the inspection outcome is marked by grades, or even more simply by using a pass or fail system. Hence, for someone without any prior knowledge, the process could be unclear because of the lack of information about the relationships between inspection visits, violations, and enforcement actions.

The main challenge in this project is a data management problem, not a policy or statistical problem. Food safety inspection data is often split across agencies, regions, and systems, and is stored in flat or weakly structured formats. Inspections are repeated over time: establishments are inspected again and again, violations can reoccur, and follow-up visits depend on earlier findings. This is important to be able to differentiate the level of the issue, between systematic error and one-time mistakes. The data involves many relationships, as each inspection visit must be linked to a specific establishment, one or more inspectors, standardised violation types, and subsequent enforcement actions such as fines, appeals, or follow-ups. In other words, the issue isn't an absence of data, but rather the absence of a defined framework to illustrate recurring events, connections, and enforcement processes over time. The objective of this project is to create a well-organized relational database that represents the food safety and restaurant inspection system in a clear, consistent, and adaptable manner.

The intended database seeks to encompass the entire lifecycle of inspections, ranging from licensing establishment and inspection visits to violations, evidence, enforcement actions, and subsequent inspections by clearly modeling entities, relationships, and cardinalities according to standard entity relationship principles. The focus is on a unified conceptual and logical database design rather than empirical analysis.

Data Management Problem Overview

Systems for food safety and restaurant inspections generate large amounts of complex data that needs to be managed across many institutions, jurisdictions, and time periods. Despite the importance of this information for consumer transparency, regulatory enforcement, and public health protection, current data infrastructures are disjointed, inconsistent and hard to combine. *This project tackles the main data management challenges involved in modeling and storing food safety inspection data within a unified relational database framework.*

A major challenge arises from the fragmentation of inspection data across agencies and regions. Different governmental organisations at the local, national, and international levels oversee food safety, which leads to the independent collection and publication of datasets. In the US, for example, state and local governments like King County, Washington State, and New York City give inspection data. It is challenging to compare inspection results, monitor compliance records, or integrate data across jurisdictions since these sources vary in structure, vocabulary, and degree of detail.

Besides fragmentation, the inspection ecosystem comprises complex relationships between many interdependent entities. The entities include establishments, inspectors, inspection institutions, inspection visits, violations, findings, evidence, fines, appeals, and follow-up actions and are linked by a combination of one-to-many and many-to-many relationships (See Appendices). Referential integrity, junction tables, and hierarchical dependencies are therefore necessary.

The regulatory and time-related factors also present the challenges in database management. Regulatory systems differ between nations and organizations, resulting in variations in definitions of violations, inspection standards, and enforcement practices. Balancing flexibility to capture differences in legislation with structure to be able to make meaningful comparisons between them is the main challenge in creating the schemas of the database. At the same time, inspection data relies on time: violations can happen in different years, licenses have specific validity durations, and follow-up actions take place after initial discoveries. As a result, we need to explicitly model time-related attributes to capture these temporal dynamics and maintain logical consistency.

In addition, various technical and conceptual issues make the management of inspection data more complicated. Variability in data formats and definitions makes integration and normalization challenging, while frequent updates to inspection records require mechanisms for versioning and historical tracking. Ensuring data integrity is critical, as relationships between inspections, violations, and enforcement actions must remain consistent and auditable. Finally, scalability and adaptability are essential, since the database must support future extensions, additional jurisdictions, and evolving regulatory requirements.

In summary, the main data management issue addressed in this project lies in designing a relational database model capable of representing fragmented, relationally complex, temporally dynamic, and regulatory-diverse inspection data. The proposed system aims to improve data consistency, traceability, and analytical potential across the food safety ecosystem.

Conceptual & Logical Database Design

Conducting food safety inspections generates a substantial amount of data. We're proposing a structure that organizes everything around the central concept of an inspection visit.

The database architecture treats each inspection event as a discrete record that links together all relevant entities and activities. Specifically, each inspection visit serves as a junction point that connects the inspected establishment, the assigned inspector, any identified violations, and subsequent enforcement actions. Therefore, our model can be considered event-centric.

The model captures both **static entities** (such as establishments, inspectors, and violation definitions) and **dynamic entities** (such as inspection visits, findings, fines, and follow-ups). Each entity is defined based on its functional role within the inspection process:

1. Establishments	Represent food businesses subject to inspection. This is the central entity of the system, as all inspection activities and enforcement actions are associated with a specific establishment.
2. Ownership	Stores information about the legal owner of an establishment (e.g., individual entrepreneur or registered company). Modeling

	ownership separately supports cases where one owner manages multiple establishments and enables owner-level accountability.
3. Address	Stores structured location information used by establishments. Separating address data reduces redundancy and improves consistency for geographic reporting.
4.Contact Information	
5. Registration	Store legal authorization information for establishments. Licenses are modeled as a separate entity to enable historical tracking of regulatory changes.
6. Inspection Institutions	Represent governmental or private organizations responsible for conducting food safety inspections. This entity supports institutional accountability, comparison across agencies, and tracking of organizational responsibility in inspection outcomes.
7. Inspectors	Represent individual agents who conduct inspection visits on behalf of inspection institutions. This entity enables tracking of inspector participation, workload, and involvement in inspection processes over time.
8. Inspection Visits	Capture time-based inspection events conducted at establishments. Each inspection visit links establishments and inspectors and serves as the core reference point for findings, evidence, and enforcement actions.
9. Violations (Catalog)	A standardized list of violation types to ensure consistent classification across inspections and regions.
10. Findings	Represent concrete violations during a specific inspection visit. Findings connect inspection visits with violation definitions.
11. Evidence	Store supporting documentation (e.g., photos or reports) related to findings.
12. Fines	Represent financial penalties imposed as a consequence of confirmed findings. This entity models enforcement mechanisms within the regulatory process.

13. Appeals	Represent legal or administrative responses to fines. This entity enables modeling of post-enforcement processes and decision outcomes.
14. Follow-ups	Record subsequent inspections conducted to verify compliance after detected violations. This entity supports longitudinal tracking of corrective actions and regulatory effectiveness.

Each entity is identified by a unique **primary key**: *establishment_id, ownership_id, address_id, contact_information_id, registration_id, institution_id, inspector_id, inspection_id, violation_id, finding_id, fine_id, appeal_id. (+ composite PK in Inspector_Inspection: inspector_id, inspection_id)*
Foreign keys enforce referential integrity:

- Registration.establishment_id → Establishment.establishment_id
- InspectionVisit.establishment_id → Establishment.establishment_id
- Inspector.institution_id → InspectionInstitution.institution_id
- InspectionVisit.institution_id → InspectionInstitution.institution_id
- Finding.inspection_id → InspectionVisit.inspection_id
- Finding.violation_id → Violation.violation_id
- Fine.finding_id → Finding.finding_id
- Appeal.fine_id → Fine.fine_id
- InspectionVisit.original_inspection_id → InspectionVisit.inspection_id (nullable)
- Inspector_Inspection.inspector_id → Inspector.inspector_id
- Inspector_Inspection.inspection_id → InspectionVisit.inspection_id
- Establishment.address_id → Address.address_id
- Establishment.ownership_id → Ownership.ownership_id
- Establishment.contact_information_id → ContactInformation.contact_information_id
- InspectionInstitution.contact_information_id → ContactInformation.contact_information_id

To ensure that the database reflects real-world inspection processes in a consistent way, the model includes several integrity constraints. Each inspection visit must be linked to an existing establishment and an inspection institution, so that inspections cannot exist independently of the entities they refer to. Inspectors are associated with exactly one inspection institution to clearly identify institutional responsibility.

Findings are defined in relation to both an inspection visit and a violation type from the violation catalog. This ensures that every recorded violation is grounded in a concrete inspection and a standardized regulatory definition. In a similar way, fines are linked to findings, and appeals are linked to fines, which mirrors the logical sequence of enforcement actions in practice. Referential integrity is maintained through foreign key relationships, while many-to-many relationships, such as between inspectors and inspection visits, are handled using junction tables in order to keep the schema normalized.

The model also takes temporal aspects into account. For example, follow-up inspections are required to take place after the original inspection, and license validity periods for the same establishment should not overlap in an inconsistent way.

The design of the model is based on several simplifying assumptions. Violation definitions are assumed to be standardized and stored in a central catalog to support consistent classification across inspections and regions. Inspections are treated as discrete events with unique identifiers, while establishments may hold multiple licenses over time, reflecting changes in their regulatory status. Evidence files, such as photos or reports, are assumed to be stored outside the database, with only references stored in the system. Finally, although regulatory frameworks differ across countries and institutions, the model assumes a common underlying structure, which makes it adaptable to different regulatory contexts.

GANTT Timeline

Weeks	Milestone / Phase	Tasks	Responsible	Deliverable
0–2	Project Setup & Concept Development	Define project purpose and scope; draft entity list and cardinalities	Everyone	Concept outline
3–4	Project Proposal	Finalize conceptual model; prepare GANTT chart; compile proposal;	Balazs, Aruzhan (Intro & Data Problem); Daryna & Azhar (Conceptual & Logical Design + GANTT)	Proposal document
5–6	Schema Implementation	Finalize table structures and attributes; implement primary & foreign keys and integrity constraints; prepare sample/synthetic data; review schema consistency and compile SQL scripts	Daryna & Balazs (attributes, tables); Azhar (constraints); Aruzhan (data); Daryna & Balazs (review and compilation)	SQL schema scripts & sample data

7–8	Project Prototype	Populate database; design basic analytical queries; create initial views; prepare data context and prototype presentation	Aruzhan & Azhar (DB); Daryna (queries & slides); Balazs (data context)	Prototype presentation & demo
9–10	Query & Procedure Development	Develop advanced analytical queries; validate queries; prepare technical documentation	Daryna (queries); Azhar (procedures); Aruzhan (testing); Balazs (documentation)	Query & procedure scripts
12	Final Presentation	Prepare live demo; structure presentation narrative; explain dataset; prepare reflection & Q&A	Everyone	Final presentation & code

Appendicies

Relationships and Cardinality

The main relationships in the conceptual model we defined are:

- **Establishment → Inspection Visit (1:N):** one establishment can have many inspection visits, but each inspection visit refers to exactly one establishment.
- **Establishment → Registration(1:N):** One establishment may have multiple registration or approval records over time, reflecting changes in regulatory status, competent authority, or ownership. Each registration record belongs to exactly one establishment.
- **Ownership → Establishment (1:N):** one owner can operate multiple establishments, while each establishment is linked to one owner.
- **Address → Establishment (1:N):** one address can be associated with multiple establishments (e.g., shared buildings), while each establishment has one address.
- **Address → Inspection Institution (1:N):**
- **Inspection Institution ↔ ContactInformation (1:1):** each institution has one contact record.
- **Establishment ↔ ContactInformation (1:1):** each establishment has one contact record.
- **Inspection Institution → Inspectors (1:N):** one institution employs many inspectors, each inspector belongs to exactly one institution (in a simplified model).
- **Inspector → Inspection Visit (M:N):** one inspector can participate in many inspection visits, and one inspection visit may involve one or more inspectors. We will implement it via an associative table: Inspector_Inspection.

- **Inspection Institution → Inspection Visits (1:N):** one institution conducts many inspection visits, each inspection visit is associated with one institution. Even though inspectors conduct inspections, institutions are responsible at an organizational level.
- **Inspection Visit → Findings (1:N):** each inspection visit may produce multiple findings, while each finding belongs to exactly one inspection visit.
- **Violation Catalog → Findings (1:N):** one violation type can appear in many findings, but each finding corresponds to a single violation definition.
- **Finding → Fine (1:0-1):** a finding may result in at most one fine. Not all findings necessarily lead to fines. Each fine refers to exactly one finding.
- **Fine → Appeal (1:N):** a fine may be appealed multiple times, while each appeal refers to one fine.
- **Inspection Visit → Inspection Visit (self-referencing 1:N):** an inspection visit may lead to zero or more follow-up inspection visits. This is represented using `original_inspection_id` in InspectionVisit, where a follow-up inspection references the earlier inspection it follows.

Constraints (implementation-level rules):

- If `inspection_type = 'follow-up'`, then `original_inspection_id` must not be NULL.
- If `inspection_type ≠ 'follow-up'`, then `original_inspection_id` must be NULL.
- Follow-up inspection date must be later than the original inspection date.
- A follow-up should reference an inspection of the same establishment (consistency rule).

In addition to the primary relationships, we identified a few indirect but conceptually important links in the model. Follow-up inspections are represented as self-referencing inspection visits; however, they remain implicitly tied to establishments, since one establishment may undergo multiple follow-up inspections over time. Similarly, appeals are formally linked to fines and findings, yet conceptually, they are actions initiated by establishments, meaning that one establishment may submit multiple appeals. Violations are also indirectly related to fines through findings, allowing analytical interpretation, such as identifying which violation types most frequently result in enforcement actions. Finally, licenses may optionally be linked to inspection visits: this reflects real-world practice where inspections are conducted under a specific license status. These indirect relationships are not always implemented as direct foreign keys but are conceptually acknowledged to strengthen the analytical and regulatory expressiveness of the database design.

Attributes

2.1 Establishment

Primary Key:

- establishment_id

Key attributes:

- name
- address_id (foreign key; separate table) → Address.address_id
- type (restaurant, café, canteen, bars etc.)
- status (active, temporarily closed, permanently closed)
- registration_date
- ownership_id → Ownership.ownership_id
- contact_information_id → ContactInformation.contact_information_id

2.2.Ownership

Primary key: ownership_id

Key attributes:

- type (entrepreneur, company,)
- owner_name (or company_name)
- ownership_identifier

2.3. Address

Primary key: address_id

Key attributes:

- city
- region
- county
- street
- postcode
- country

2.4 Registration

Primary Key:

- registration_id

Foreign Key:

- establishment_id → Establishment.establishment_id

Attributes:

- registration_type (registration vs approval)
- competent_authority (HSE EHS / DAFM / SFPA)
- registration_number (or approval_number) — unique per authority
- issue_date
- end_date (NULL if still active)
- status (valid, suspended, revoked, expired)

2.5 Inspection Institution

Primary Key:

- institution_id

Attributes:

- name
- address_id (foreign key; separate table) → Address.address_id
- institution_type (HSE EHS, local authority unit, other competent authority)
- jurisdiction_area (e.g., county/region)
- contact_information_id

2.6 Contact information

Primary Key:

- contact_information_id

Key attributes:

- phone
- email
- website

2.7 Inspector

Primary Key:

- inspector_id

Foreign Key:

- institution_id

Attributes:

- name
- qualification_level ()
- employment_start_date
- employment_status

2.8 Inspection Visit

Primary Key:

- inspection_id

Foreign Keys:

- establishment_id → Establishment.establishment_id
- institution_id → InspectionInstitution.institution_id
- original_inspection_id → InspectionVisit.inspection_id (nullable)

Attributes:

- inspection_date
- inspection_type (routine, complaint-based, follow-up)
- overall_score
- enforcement_action_type (none / closure_order / prohibition_order / improvement_order)
- outcome_status (compliant, non-compliant, conditional pass)
- original_inspection_id (NULL if not a follow-up; otherwise points to the inspection being followed up)
- supplier_verification_status *(not_checked / verified / issues_found / needs_follow_up)*

Interpretations / constraints

- If inspection_type = 'follow-up', then original_inspection_id **must not be NULL**.
- If inspection_type ≠ 'follow-up', then original_inspection_id **must be NULL**.
- A follow-up inspection must reference an inspection of the **same establishment** (consistency rule).
- The follow-up date must be **later** than the original inspection date.

2.9 Inspector_Inspection (Associative Table)

Primary Key (composite):

- inspector_id
- inspection_id

Foreign Keys:

- inspector_id → Inspector.inspector_id
- inspection_id → InspectionVisit.inspection_id

2.10 Violation (Catalog)

Primary Key:

- violation_id

Attributes:

- code
- description
- severity_level (very satisfactory, satisfactory, 2 other)
- risk_category (temperature, …)
- legal_reference (to reflect regulatory grounding) ()

2.11 Finding

Primary Key:

- finding_id

Foreign Keys:

- inspection_id
- violation_id

Attributes:

- severity_assessed
- notes (evidence)
- status (open, resolved, pending review)

2.12 Fine

Primary Key:

- fine_id

Foreign Key:

- finding_id

Attributes:

- amount
- issue_date
- due_date
- payment_status (paid, pending, overdue)

2.13 Appeal

Primary Key:

- appeal_id

Foreign Key:

- fine_id

Attributes:

- appeal_date
- decision_date (for process completeness)
- outcome (approved, rejected, partially approved)

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