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FROM THE EXAMINATION TO THE IMPROVEMENT OF SANITARY CONDITIONS IN UNDERPRIVILEGED NEIGHBOURHOOD: THE CASE OF EL ZAOUIA IN TÉBESSA, ALGERIA

Abstract: This paper examines the public health conditions in the underprivileged neighbourhood of El Zaouia in Tébessa, where residents face major challenges such as limited access to potable water and inadequate sanitation infrastructure, increasing the risk of waterborne diseases (cholera, typhoid). The lack of effective waste management and drainage systems exacerbates living conditions, fostering the proliferation of disease vectors and increasing flood risks. Additionally, the use of substandard construction materials exposes inhabitants to respiratory illnesses due to humidity and mould. The objective of this research is to analyse the sanitary conditions in this neighbourhood and propose concrete, context-specific solutions to improve living conditions. This study is based on an in-depth analysis of the specific public health challenges in the area. To achieve this, we conducted fieldwork combining direct observation and questionnaire-based surveys with residents, allowing us to collect both qualitative and quantitative data. The findings will facilitate the development of actionable recommendations applicable to El Zaouia and potentially adaptable to other underprivileged neighbourhoods in Algeria.

Keywords: sanitation, waste management, potable water, storm water management, construction materials, El Zaouia neighbourhood

Introduction

The urban housing deficit crisis poses a significant challenge for cities worldwide, driving the rapid proliferation of precarious urban areas. This phenomenon has intensified in several Algerian cities at different periods and in various urban forms (CITEGO, 2007). These settlements, referred to globally as slums, favelas, barrios, Gecekondus, invasiones, villas

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miserias, pueblos jóvenes, kebbé, and achwaiya (Serrab-Moussanef, 2006; Clerc & Deboulet, 2018; Mebirouk & Mebirouk, 2022), are characterized by unregulated urban expansion, a lack of essential infrastructure, and substandard living conditions (Navez-Bouchanine, 2007; Deboulet, 2016; Moles, 2018).

Common features of these areas include self-built housing constructed from non-durable materials, often failing to comply with structural, safety, and sanitation standards. High-density occupation exacerbates public health concerns, while inadequate access to potable water, wastewater management, electricity, and transportation systems further deteriorates living conditions. The socio-spatial marginalization of these communities deepens urban inequalities, as residents remain excluded from formal urban planning and development policies (Navez-Bouchanine, 2007; AFD, 2014). The absence of resilient infrastructure and integrated service networks exposes these populations to heightened environmental and health risks. According to UN-Habitat (2001) and Deboulet (2016), nearly one billion people worldwide live in such conditions, where exposure to waterborne and vector-borne diseases is aggravated by insufficient sanitation systems and environmental degradation.

In the Algerian context, the city of Tébessa is a good illustration of this problem. Rapid demographic growth as a result of the rural exodus has encouraged the emergence of unplanned settlements, exacerbating urban precarity (PDAU, 2009). The El Zaouia neighbourhood is particularly affected by these issues, with its residents facing a number of difficulties: poor infrastructure, inadequate access to drinking water, lack of adequate sewage systems and inefficient waste management (Douib & Mebirouk, 2023).

It is important to note that access to potable water and sanitation is a critical global challenge for many nations, yet it remains a daily struggle for hundreds of thousands of urban dwellers, particularly in developing countries (Djuissi Tekam et al., 2019). This situation has severe public health implications, contributing to a heightened prevalence of diarrheal diseases, infections, and hygiene-related illnesses (Durand-Lasserve, 1988; Araba, 2012).

Moreover, the lack of access to clean water and basic sanitation facilities leads to inefficient resource management and forces residents to rely on precarious solutions, further increasing their vulnerability to health risks (Savina & Mathy, 1994). Poor hygiene conditions and exposure to pathogens negatively impact the population's overall quality of life, both immediately and in the long term.

This raises a central question: What are the specific public health challenges faced by the residents of El Zaouia, and what measures can be implemented to improve these conditions? Analysing these issues will provide a deeper understanding of the health implications of urban precarity and help identify intervention strategies to enhance the quality of life in these neighbourhoods.

Health Risks in Precarious Urban Settings: A Theoretical and Analytical Synthesis of Scientific Research

The emergence of precarious urban areas results from a complex interplay of factors such as demographic pressure, persistent poverty, and uncontrolled urbanization (AFD, 2014; Mebirouk, 2018; Nait-Amar, 2022). These environments, marked by deteriorating living conditions, expose residents to a wide range of health risks. Unsanitary conditions, lack of essential

infrastructure, and exposure to various contaminants foster the spread of diseases, severely undermining collective well-being (UN-Habitat, 2020; Agofak Clarisse et al., 2023).

In the scientific literature, health risk is defined as the probability that an event or situation will harm the health of an individual or a population (Géoconfluences). It is essential to analyse these risks in order to devise appropriate prevention and intervention strategies. Several categories of risk come together in these contexts. Infectious risks, linked to the presence of pathogens, are exacerbated by the lack of access to drinking water and sanitation infrastructure, facilitating the onset of diseases such as cholera and diarrhoea (INSPQ, 2018; Dongo et al., 2008; Sy et al., 2011). Chemical risks, for their part, result from exposure to toxic substances (pesticides, industrial pollutants, asbestos), and are associated with chronic diseases, particularly cancers and respiratory disorders (CNRS, 2024). Environmental risks include both natural disasters (floods, heat waves) and industrial pollution, which exacerbate health vulnerabilities (HAS, 2023). Biological risks, linked to exposure to waste and sewage, represent a major source of infections in areas where waste management is poor (CSN, 2014). Finally, dietary risks, caused by the consumption of contaminated food, contribute to the increase in digestive diseases (WHO, 2024).

In these environments, these risks overlap and reinforce each other. The absence of adequate sanitation systems not only amplifies water-borne diseases, but also contributes to air and soil contamination, intensifying the impact of chemical and biological agents. Air pollution, caused mainly by the combustion of waste in the absence of collection systems, releases toxic compounds responsible for respiratory problems and chronic illnesses such as asthma and bronchitis (Hacini-Chikh & Mebirouk, 2004; Koffi et al., 2013). Overcrowded conditions and poor ventilation in housing further exacerbate these respiratory ailments.

The health consequences in these contexts are significant. Epidemics of tuberculosis, hepatitis and diarrhoeal diseases are recurrent, mainly affecting children and the elderly, who are particularly vulnerable (Dongo et al., 2008; Sy et al., 2014). In addition, the lack of access to healthcare increases the severity of infectious and chronic diseases, exacerbating health inequalities.

Recent research confirms these observations. The World Health Organization (WHO, 2019a) identifies the lack of safe access to drinking water and sanitation infrastructure as a major vector for the transmission of water-borne diseases, such as diarrhoea, cholera or typhoid fever. Open-air excreta disposal practices and the use of contaminated water sources exacerbate these exposures. In addition, unsanitary conditions linked to the lack of structured waste management encourage the proliferation of pathogenic vectors, such as mosquitoes, which carry malaria and dengue fever, and rodents, which are responsible for leptospirosis (UN-Habitat, 2021).

Indoor air pollution, resulting from the use of solid fuels (wood, coal) for cooking and heating, is another critical threat. These practices generate high concentrations of fine particles and carbon monoxide in often confined spaces, increasing the risk of chronic obstructive pulmonary disease (COPD), acute respiratory infections and asthma, particularly in children and the elderly (Smith et al., 2013).

Using a systems approach, work by the National Academies of Sciences, Engineering, and Medicine (2018) analyses the dynamics of informal urban environments in the resur-

gence of infectious diseases. It highlights the decisive role of high population density, deficits in health infrastructure and poor housing conditions in accelerating the transmission of pathogens, particularly tuberculosis, respiratory infections and dermatological diseases. Overcrowding and poor ventilation intensify the spread of disease and lead to psychosocial tensions that affect the mental health of residents.

However, local initiatives are emerging to mitigate these risks. The Borgen project, run in the slums of Kibera by the NGO Shining Hope for Communities (SHOFCO), is a prime example. This programme combines improved access to drinking water, sanitation and education with awareness-raising activities, reducing health exposure and strengthening community resilience (Entraide Missionnaire, 2024).

These studies converge toward a unanimous conclusion: health risks in precarious urban environments stem from a convergence of adverse environmental, infrastructural, and socio-economic factors. Mitigating these risks requires a sustainable approach that integrates appropriate infrastructure, efficient waste management, access to healthcare, and health education, supported by inclusive and long-term public policies.

From this perspective, the analysis of the El Zaouia neighbourhood in Tébessa offers valuable insights. Characterized by high population density and inadequate infrastructure, this area represents a typical example of the dynamics found in informal settlements. Studying it helps to better understand the mechanisms that exacerbate health risks and contributes to the broader body of scientific knowledge on public health in Algeria's vulnerable urban contexts. The findings from this analysis could inform the development of targeted intervention strategies at both local and national levels, with the aim of sustainably improving living conditions for vulnerable populations.

Study Area

The city of Tébessa serves as the administrative centre of a border wilaya, located in its northeastern region. It covers a total area estimated at 184 km² (Hajla, 2017) and had a population of approximately 245,409 inhabitants according to the 2021 census (Fig. 1).

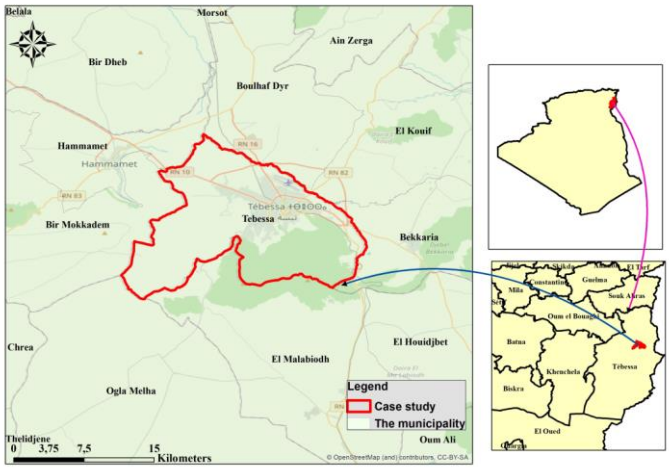

Fig. 1. Location of the city of Tébessa (Authors)

Tébessa is characterized by a significant expansion of unplanned and precarious housing, stretching from the city center to the outskirts and distributed across several districts, including El Zaouia, El Zitoune, El Mizeb, L'Aqueduc, La Gare, Rafana, and Bab El Zatine, as illustrated in (Fig. 2).

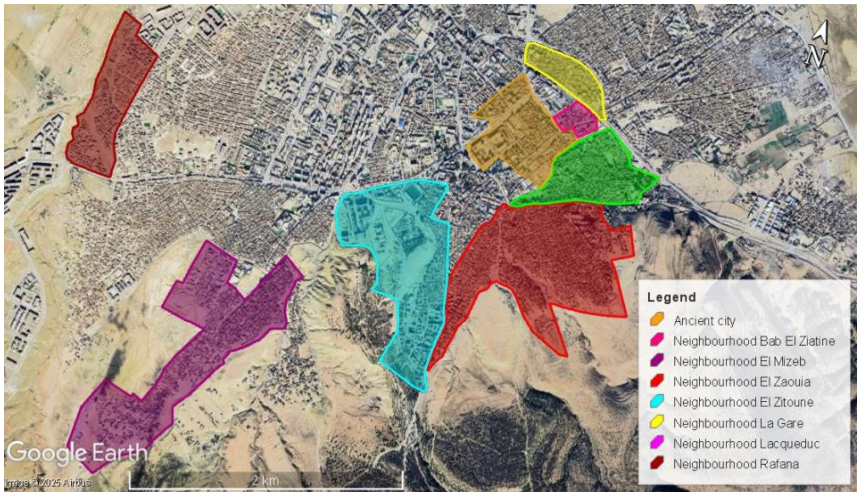

Fig. 2. Precarious settlements in the city of Tébessa (Authors)

This study focuses on the precarious district of El Zaouia, the oldest unplanned settlement in the city, established in 1970. This neighbourhood is distinguished by severe lack of infrastructure, making it one of the most marginalized areas in Tébessa. No intervention has been carried out by local authorities, leaving residents to live in extremely precarious conditions. According to 2008 statistics, El Zaouia housed approximately 8,250 residents distributed across 1,315 dwellings, representing 32.16% of the total number of marginal housing units in the city (Boulmaiz, 2022).

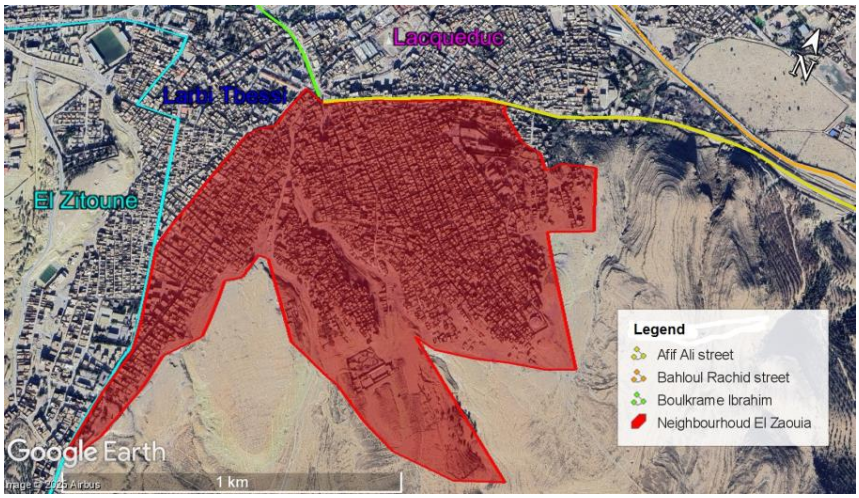

Fig. 3. Geographic location of the study Area – El Zaouia district (Authors)

Located in the southeastern part of Tébessa, El Zaouia is surrounded by other marginalized neighbourhoods (Fig. 3). Despite being only 600 meters from the city centre, it covers an area of 55.8 hectares, highlighting a stark contrast between its marginalized state and its proximity to the urban core. The neighbourhood is characterized by two types of housing: informal dwellings, constructed spontaneously without legal authorization and outside urban planning regulations (PDAU, 2009), and precarious housing near the oued, consisting of 40 dwellings built with low-quality materials.

Methodological Approach

This research aims to analyse living conditions in the El Zaouia neighbourhood, identifying the main challenges linked to access to drinking water, sanitation, waste and rainwater management, as well as their health repercussions. The aim is to propose concrete courses of action to improve the quality of life of local residents.

The study is based on a two-pronged methodological approach:

- A contextual analysis, which provides a detailed overview of the district by examining its urban, social and environmental characteristics, in order to gain a better understanding of local needs and dynamics.
- An analysis of vulnerability factors, focusing on health risks and social determinants, exploring the causes, effects and mechanisms that contribute to the precariousness and health problems of local residents.

This cross-disciplinary approach provides a comprehensive and detailed understanding of the issues facing the district, combining quantitative and qualitative tools.

Data collection and analysis methods

Quantitative data: Household survey

Although the sample size may appear limited in relation to the total population, it is methodologically justified on several grounds. Firstly, the family structure in the neighborhood allows for indirect representativeness: each household head effectively speaks on behalf of 4 to 6 individuals, thereby extending the actual data coverage to approximately 400 to 600 people. Secondly, the homogeneity of the social, residential, and economic fabric of El Zaouia, characterized by widespread precarity and high-density housing, reinforces the internal consistency of the responses collected.

The survey quickly reached a point of data saturation: respondents' answers showed significant redundancy, with no new significant elements emerging beyond a certain threshold. This phenomenon, well-documented in qualitative research methods (Glaser & Strauss, 1967), justifies the cessation of data collection once thematic repetition becomes sufficient.

Ultimately, the study adopts an exploratory research approach, in which the objective is not statistical generalization but rather the identification of trends, social representations, and territorial dynamics. In this context, as emphasized by Quivy and Van Campenhoudt (1995), the relevance of observations outweighs the numerical size of the sample. This type of methodological adaptation is also widely employed in research conducted in precarious or informal neighbourhoods across the Maghreb region (Rémy & Voyé, 1992), where field conditions often necessitate flexible standards.

In sum, despite its modest numerical size, the selected sample offers sufficient analytical and contextual value to capture the main issues experienced by the residents of El Zaouia.

The survey focused on two sub-areas of the district:

- the precarious area (40 dwellings), surveyed in its entirety;
- and the informal area (30 dwellings), selected on the basis of the results of field observations and interviews.

The investigations revealed a strong similarity between the residents of the two zones, characterised by:

- unregulated housing (often without planning permission);
- lack of connection to the drinking water and sewerage networks;
- inadequate waste management;
- precarious socio-economic conditions (unemployment, low income);
- as well as situations of insecurity, marginalisation and spatial isolation.

Although there are some differences between these dwellings (particularly in terms of structure (number of rooms, floors) and building materials), the living conditions remain comparable, justifying the selection of this sample. This approach guarantees the reliability and relevance of the results obtained, while enabling a targeted analysis of the needs and challenges encountered.

To frame the survey, we used a structured questionnaire based on the model developed by the United Nations UN-Habitat programme (2020), initially applied to the precarious neighbourhoods of Conakry (Guinea). However, in order to better respond to the local specificities of the El Zaouia neighbourhood, we adapted this model by including an additional section on health impacts, which was missing from the original version. This adaptation is based on several considerations:

- the methodological relevance and robustness of the UN-Habitat model for assessing precarious housing situations;
- the structural and socio-economic similarities between Conakry's neighbourhoods and that of El Zaouia;
- and the need to specifically address the links between living conditions and public health in this neighbourhood.

The questionnaire, which was administered in person, consisted of 27 closed, open and pre-coded questions, divided into a progressive structure ranging from general to more specific questions. The themes covered were organised into four main sections (Table 1):

Table 1. Analysis of Living Conditions and Health in the El Zaouia District

Number	Sections	Indicators
1	Demographic data	Gender, age, place of birth, occupation, and reasons for migration.
2	Housing conditions	Surface area, number of floors, number of rooms, type of property, and construction materials.
3	public health conditions	Access to drinking water, wastewater disposal methods, waste management, stormwater management, and access to healthcare and educational facilities.
4	Health impacts	Diseases caused by water quality, poor waste management, lack of ventilation, and flooding.

Source: Authors

These indicators have been carefully selected to provide a comprehensive and in-depth assessment of the impact of living conditions on the health of residents. The ultimate aim of this approach is to put forward appropriate recommendations for improving the living conditions and health resilience of the residents of the El Zaouia district over the long term.

Qualitative data

Field observations

Direct observations were carried out over four consecutive days throughout the neighbourhood, with particular attention paid to the most vulnerable areas. The observations focused on:

- Sanitation infrastructure (pipes, wastewater disposal, non-existent connections);
- Drinking water supply (presence or absence of connections, effective access to water);
- Waste management (frequency of collection, illegal dumping, storage facilities);
- Condition of buildings (healthiness, solidity, interior and exterior habitability).

An additional visit was made during the rainy season to assess drainage capacity and flood risks, in particular the state of the wadi and water accumulation points. These observations provide a concrete and contextualised view of the health and urban issues at stake.

Semi-structured interviews

In-depth interviews were conducted with several categories of stakeholder:

- Local residents

Twelve interviews were conducted in June 2023 with residents selected according to their vulnerability (state of housing, sanitation situation, proximity to the wadi), including men, women and young people. The interviews, which were conducted without audio recording at the request of the participants, were noted down manually and provided an opportunity to hear people's accounts of their day-to-day difficulties.

- Institutional players

Semi-structured interviews were conducted with institutional players and health professionals in June and July 2023 respectively, lasting between 60 and 90 minutes, in order to gather their analyses of urban and health conditions in the district under study. Table 2 provides a summary.

Table 1 . Summary of interviews conducted with public stakeholds.

Stake-holders	Participants	Objectives	Main topics discussed
Public Admin-istra-tions	-Head of the Directorate of Urbanism and Construction (strategic vision on informal settlements, development projects, and intervention plans) -Head of the Office for Informal Housing (technical expertise and monitoring of non-regulated constructions)	-Identify the institutional perception of urban, health, and social issues related to informal settlements.	-Assessment of health risks - Socio-economic and infrastructural challenges- Ongoing or planned corrective actions- Recommendations for improving living conditions
Health Profes-sionals	- Preventive Care Physician-Pulmonologist (clinical experience with diseases linked to precarious environments: respiratory illnesses, etc.)	-Gather clinical and epidemiological insights on prevalent pathologies and local health risks.	- Epidemiological profile of residents - Environmental determinants of prevalent diseases - Context-specific prevention strategies

Source: Authors

In order to strengthen the robustness of the study, rigorous techniques were used throughout the data collection process. In-depth interviews, detailed questionnaires and direct observations were used to gather precise qualitative and quantitative information. Furthermore, the findings were systematically compared with those of other studies conducted in similar contexts, in order to assess their coherence and relevance. These comparisons focused on two international experiences: the Integrated Urban Project (Proyecto Urbano Integral, PUI) in Medellín, Colombia, which enabled the upgrading of informal settlements through improvements in basic infrastructure, relocation strategies, and the integration of transport systems; and the "Lalan'kely" project in Antananarivo, Madagascar, which emphasized sanitation, drainage, community-based waste management, and intermunicipal coordination within the framework of the "Fiftama" initiative.

Sampling-related margins of error were taken into account during the analysis. Within a qualitative and contextual approach, this ensures a satisfactory level of interpretative relevance and fidelity of the results to the actual living conditions experienced by residents of the El Zaouia neighbourhood.

Data Processing

Quantitative data were analysed using Sphinx Plus V5 software. After manually entering the responses, univariate analysis was used to generate statistical tables (frequencies, percentages) to identify the main trends and difficulties. The results were presented in the form of tables and graphs.

Qualitative data (interviews, observations) were processed using NVivo software, to extract the major themes, the perceptions of residents and the solutions proposed by institutional players.

Research Results

Quantitative data by questionnaire

The quantitative data obtained by questionnaire are analysed according to the four themes selected in the analysis grid: demographic data, housing conditions, sanitary conditions and effects on health.

Demographic Data

Field survey results highlight a significant predominance of residents originating from neighbouring towns, representing 70% of El Zaouia's population. This indicates a migration dynamic primarily driven by rural exodus. In contrast, 30% of residents are originally from the city of Tébessa, suggesting a more limited intra-urban migration.

The motivations behind this migration to Tébessa vary, with employment opportunities accounting for 30%, housing accessibility for 19%, proximity to essential services for 34%, and security concerns for 17% (Fig. 4).

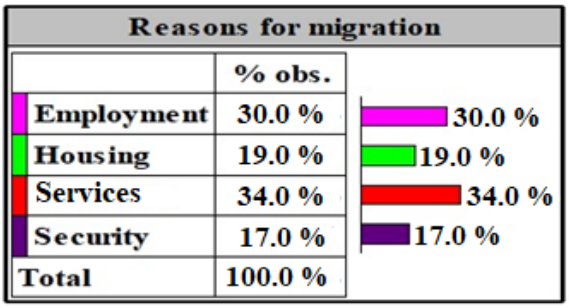

Fig. 4. Reasons for migration (Field Survey, 2023)

These findings illustrate the complexity of migration patterns, where socio-economic and infrastructural factors play a crucial role in determining settlement choices.

The field survey also highlights that most residents occupy municipal land illegally, underscoring widespread land tenure insecurity in El Zaouia. Family structure analysis reveals a predominance of nuclear families, comprising 69% of households, who live independently without cohabiting with extended relatives.

However, 12% of families adopt a parallel housing arrangement, characterized by the absence of official land tenure while sharing accommodation with brothers. Additionally, 19% of families comprise multi-generational households, where married children and widowed parents cohabit, reflecting strong intergenerational housing arrangements (Fig. 5). These findings highlight diverse residential strategies influenced by land constraints and family solidarity dynamics.

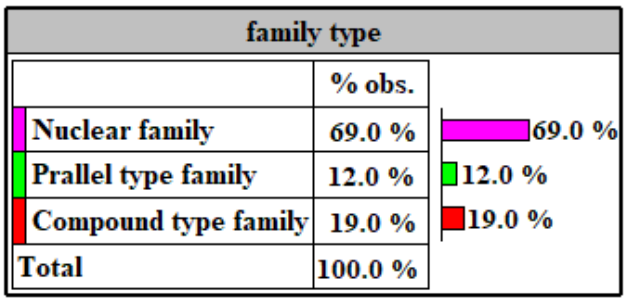

Fig. 5. Family structure in El Zaouia (Field Survey, 2023)

Demographic analysis of El Zaouia reveals a precarious socio-economic situation, marked by a high unemployment rate reaching 40%. This reflects significant economic challenges that impact residents' living conditions.

The district's workforce is predominantly composed of manual laborers, representing 36% of the working population, followed by retirees (11%). Meanwhile, employees account for only 13%, indicating limited integration into stable and skilled employment sectors (Fig. 6). These figures highlight a pronounced socio-economic vulnerability, where restricted access to formal employment is a key factor contributing to precarious living conditions.

Occupation		
	% obs.	
Workers	36.0 %	36.0 %
Unemployed	40.0 %	40.0 %
Employees	13.0 %	13.0 %
Retired	11.0 %	11.0 %
Total	100.0 %	

Fig. 6. Occupational distribution of El Zaouia residents (Field Survey, 2023)

Housing Conditions

An analysis of housing conditions in El Zaouia reveals two main types of constructions, differentiated by their durability and the materials used.

Solid constructions: (this term refers solely to the physical solidity of the buildings). These dwellings, of which there are 30, are characterised by a load-bearing structure made up of reinforced concrete posts and beams, as well as rough concrete walls, often without plaster or rendering. Despite their apparent structural solidity, however, they have no legal recognition and are not formally integrated into the planned urban fabric. This is because they have been built outside the regulatory framework, without obtaining planning permission or official authorisation from the relevant authorities.

Precarious constructions: These 40 dwellings are considered precarious due to the use of lightweight, low-strength materials such as breeze blocks and bricks, combined with corrugated iron or fibre cement roofs. In addition, the lack of solid foundations and appropriate load-bearing structures compromises their stability, making them particularly vulnerable to climatic conditions and exposed to a real risk of collapse (Serrab-Moussanef, 2006, Navez-Bouchanine, 2007, Mebirouk, 2018).

The building typology indicates a predominance of single-story dwellings (R+0), which make up 64% of the housing stock. One-story constructions (R+1) represent 21%, while two-story buildings (R+2) are rarer, accounting for only 15%.

In terms of surface area, most dwellings (69.2%) cover between 50 and 100 m². Larger dwellings exceeding 100 m² remain a minority (9.7%), whereas those below 50 m² represent 21.1%, illustrating significant spatial heterogeneity in housing distribution. The number of rooms per dwelling also reflects this diversity:

- 47% of homes have fewer than three rooms,
- 10% contain three rooms,
- 16% have four rooms,
- 12% feature five rooms,
- 15% have more than five rooms.

Regarding property ownership, most dwellings, particularly self-built ones, lack official land titles, limiting their integration into regulatory frameworks and restricting access to public services and formal financing.

Fig. 7. Distribution of roofing materials in precarious housing (Corrugated metal and fiber cement) in El Zaouia (Field Survey, 2023)

An analysis of construction materials confirms the predominance of brick, used in 69% of cases, followed by reinforced concrete (19%) and cinder block (12%) (Fig. 7). For roofing, reinforced concrete is the most common (50%), followed by fiber cement (43%) and corrugated metal sheets (7%), highlighting disparities in housing quality and thermal comfort (Fig. 8).

Fig. 8. Use of construction materials for housing envelopes (Brick and Cinder Block) in El Zaouia (Field Survey, 2023)

These observations underscore the structural and material diversity of El Zaouia's housing stock, reflecting informal construction trends and socio-economic constraints faced by residents.

Sanitary Conditions

Access to drinking water and sanitation network connection

Analysis of drinking water supply conditions in the El Zaouia neighbourhood shows a marked disparity between informal settlements and precarious housing. Most informal housing is connected to a relatively structured network, guaranteeing direct access to drinking water. On the other hand, insecure housing remains excluded from this infrastructure and relies on alternative solutions. Thus, 64.0% of households obtain their water from cisterns, while 14.0% obtain water from their neighbours. A minority (22.0%) use other means to meet their water needs (Fig. 9).

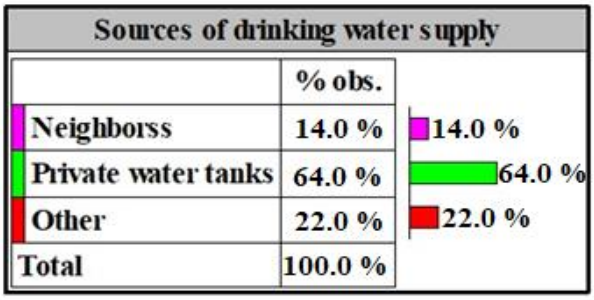

Fig. 9. Water supply system in El Zaouia (Field Survey, 2023)

The sanitation situation also reveals significant shortcomings. Only half the homes in the neighbourhood are connected to the public network managed by the local authority. Households that are not connected adopt practices that pose health and environmental risks: 22.0% of households discharge their wastewater directly into the street, while 28.0% discharge it into the wadi, thereby contributing to the pollution of the natural environment (Fig. 10 and 11).

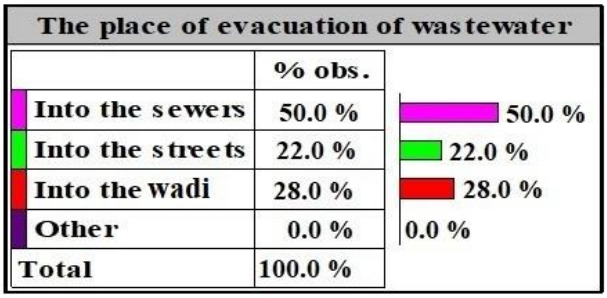

Fig. 10. Wastewater disposal System in El Zaouia (Field Survey, 2023)

Fig. 11. Wastewater discharge into the Oued. Source: (Field Survey, 2023)

These findings reveal the poor management of basic infrastructure, exacerbating the health vulnerability of local residents, particularly through the spread of water-borne diseases

and poor hygiene. They also exacerbate the deterioration of the local environment, due to soil and groundwater pollution linked to the lack of drainage and wastewater treatment systems.

Household Waste Management in El Zaouia

The analysis reveals a lack of waste management in the El-Zaouia neighbourhood. Only 10.0% of residents use the designated drop-off points, while 7.0% dispose of waste in vacant lots, undeveloped areas or street corners, often located behind dwellings. The majority, 83.0%, dispose of their waste directly into the wadi, due to the lack of a suitable collection system.

This situation is exacerbated by the inaccessibility of collection trucks in certain areas, due to the narrowness of the roads and the lack of appropriate infrastructure. These practices lead to the degradation of ecosystems, air pollution and the proliferation of insects and rodents, thereby increasing health risks (Fig. 12). Incineration, used by some residents to reduce the volume of rubbish, also contributes to air pollution and respiratory and chronic diseases (Fig. 13 and 14).

Places for household waste dumping

	% obs.
In designated areas	10.0 %
In the wadi	83.0 %
Other	7.0 %
Total	100.0 %

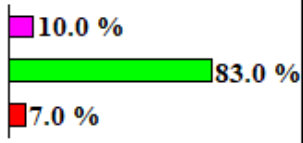

Fig. 12. Household waste disposal sites (Field Survey, 2023)

Fig. 13. Household waste dumping in the Oued in El Zaouia (Field Survey, 2023)
Fig. 14. Household waste incineration (Field Survey, 2023)

Vulnerability of El Zaouia homes to floods

An analysis of the layout of the homes in the El Zaouia district reveals that 63.0% of them are located near a wadi (About 4 metrs), making them more exposed to flooding, particularly during the winter season, when rainfall is intense. Increased run-off in the neighbourhood's streets and alleyways encourages erosion of the surface layers of the soil, a phenomenon that further weakens built structures. This instability is exacerbated by the

shallowness of the foundations and the nature of the building materials, which are often not very resistant.

This vulnerability has many consequences. Soil degradation compromises the stability of homes, increasing the risk of collapse. In addition, flooding increases the dangers for residents, particularly due to the risk of drowning and electrocution associated with the presence of precarious electrical networks in a damp environment.

Indirect effects have also been observed, notably the loss of material goods such as furniture and household appliances, losses that are difficult to compensate for given the low incomes of residents. Dampness, caused by water infiltration and lack of adequate ventilation, encourages the proliferation of mould on walls and ceilings, with significant health repercussions. Residents, particularly the elderly and children, are more exposed to respiratory diseases and chronic allergies.

These cumulative factors make this area particularly exposed to environmental hazards, with significant impacts on the safety and living conditions of residents (Fig. 15).

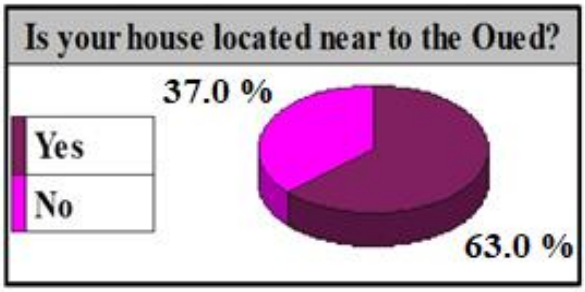

Fig. 15. Proximity of housing to the Oued in El Zaouia (Field Survey, 2023)

Storm water Drainage Systems in El Zaouia

The lack of drainage infrastructure in El Zaouia significantly exacerbates the stormwater evacuation problem, particularly during winter months. The absence of a structured drainage network leads to prolonged water stagnation in the district's streets and alleys. This accumulation encourages the proliferation of disease-carrying insects, particularly mosquitoes, increasing public health risks for residents.

Additionally, the interaction between stagnant water and improperly discarded waste intensifies the spread of foul odors and pathogenic agents, further worsening Additionally, the interaction between stagnant water and improperly discarded waste intensifies the spread of foul odors and pathogenic agents, further worsening environmental health hazards.

From a mobility perspective, the degraded condition of unpaved roads exacerbates movement difficulties for residents. During heavy rainfall, streets become muddy pathways, making navigation challenging and increasing the risk of slips and falls, especially for children and the elderly. The lack of proper urban planning and infrastructure thus heightens the vulnerability of residents to environmental and health risks, underscoring the urgent need for storm water management interventions and urban rehabilitation.

Health Impacts

Waterborne, Wastewater, and Waste-Related Diseases

The deterioration of environmental conditions in the El-Zaouia district, particularly the poor management of drinking water, wastewater and waste, is a determining factor in the emergence of pathologies affecting the population. Prolonged exposure to these nuisances encourages the spread of various diseases, the prevalence of which is significant.

Analysis of the data reveals the presence of several diseases among residents, the breakdown of which is shown in Table 3.

Table 2. Breakdown of illnesses reported by residents of the El Zaouia neighbourhoud

Type of Disease	Number of People Affected	Percentage of Residents	Manifestations
Allergic diseases	20	24,7 %	Allergies are the most common among the residents.
Ophthalmic diseases	18	22.7%	Eye irritations.
Dermatological diseases	13	13.4%	Repeated exposure to pathogens or irritating substances present in the environment.
Waterborne diseases	10	12.4%	Notably hepatitis A.
Respiratory diseases (asthma)	8	10.3%	Asthma, a concerning issue.
Respiratory diseases (bronchitis)	6	7.2	Bronchitis, linked to air quality and living conditions.
Gastrointestinal diseases	8	9.3	Digestive disorders related to hygiene conditions.

Source: Authors

These figures underline the urgent need for sanitation measures and sustainable management of water resources to limit the health impact of this environmental degradation.

Healthcare Services

The total absence of health infrastructure in the El Zaouia neighbourhood, confirmed by all respondents (100%), highlights a major failure in the local health system. This structural deficiency creates multiple constraints for residents, both economically and in terms of health. In the absence of local health centres, residents are forced to travel long distances, ranging from 3.45 to 4.53 kilometres, to reach the nearest health centre. These include the Alia Salah, Bachir Mentouri, Tayeeb Hussein Ben Abbouda (Doukan), Mensel Khadidja (Skanska), and Rocade polyclinics, as well as the Khaldi Abdelaziz hospital. This corresponds to an estimated journey time of between 40 and 60 minutes on foot. What's more, they have to bear additional costs to access medical services, which adds to their burden, particularly for the most vulnerable populations.

This situation presents a major public health challenge as healthcare accessibility is a fundamental component of community well-being. The lack of healthcare facilities not only

delays medical intervention, worsening chronic conditions, but also reinforces health disparities. Thus, the absence of healthcare infrastructure in the district is not merely a logistical constraint; it actively contributes to the deterioration of residents' overall health conditions.

Qualitative data from semi-structured interviews

Semi-structured interviews were conducted with four key stakeholders:

1. Head of the Informal Housing Bureau – Actor 1
2. Respiratory Disease Specialist – Actor 2
3. Director of Urban Planning and Construction – Actor 3
4. Preventive Medicine Physician – Actor 4

These interviewees were selected based on their professional roles and years of experience, ensuring a diverse perspective on health and urban planning issues in El Zaouia.

The interviews focused on: causes of health risks, common diseases, residential building resilience to floods, daily risk reduction measures, and current or planned interventions.

Data analysis was conducted using NVivo software, allowing structured coding of qualitative responses.

The results of the qualitative analysis of stakeholder responses obtained via NVivo (Fig. 16) reveal both convergences and divergences in their perceptions regarding the major causes of health risks in the El-Zaouia neighborhood. The primary shared concerns include the absence of sanitation systems and poor waste management, both of which are considered aggravating factors that deteriorate living conditions and facilitate the spread of diseases. However, specific divergences emerge: poor water quality is mentioned by three stakeholders, while two highlight inadequate ventilation in residential buildings. Other stakeholders point to the absence of storm water drainage and the use of unsuitable construction materials as additional issues, though these concerns are not universally shared.

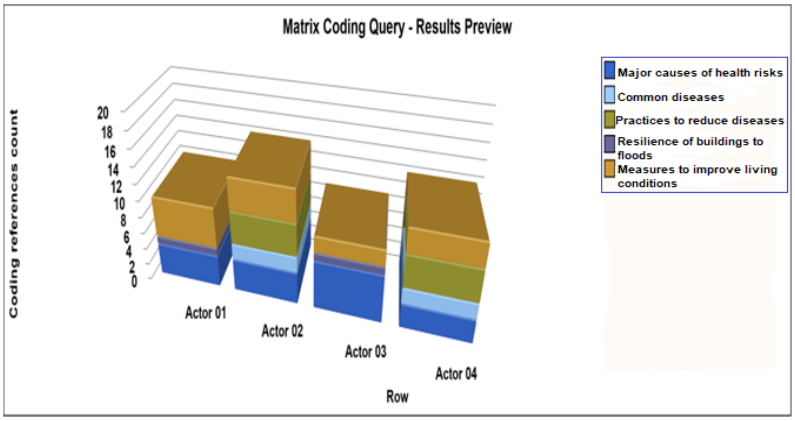

Fig. 16. Findings from semi-structured interviews (Authors)

On the subject of common illnesses in the neighbourhood, the responses from the four stakeholders show certain points of convergence. Stakeholders 1 and 3 did not provide an answer, believing that this aspect did not fall within their area of expertise, which limits their ability to make an assessment. Stakeholder 2 identified several pathologies, including respiratory disorders, water-borne diseases and skin conditions. Stakeholder 4 shared similar concerns, also mentioning respiratory and waterborne diseases, as well as allergies.

The perceptions of Stakeholders 1 and 3 converge on the vulnerability of buildings in the El-Zaouia neighbourhood to flooding. Actor 3 emphasised the inability of existing buildings to withstand the risks effectively, while Actor 1 mentioned frequent exposure to flooding, without going into details. Stakeholders 2 and 4 did not express an opinion, their areas of intervention being more focused on medical and preventive aspects than on structural or urban planning issues. These elements underline the need to strengthen the district's infrastructure, in particular by improving building materials.

The proposals of the four stakeholders for improving public health in El-Zaouia reflect diverse approaches. Stakeholder 3 prioritizes comprehensive structural solutions, such as building rehabilitation, improving sanitation and drainage networks, and ensuring access to clean water. They also emphasize land regularization and community involvement. Stakeholder 2 focuses on hygiene awareness and the establishment of basic infrastructure, particularly local health centres. Stakeholder 1 highlights the importance of storm water and waste management, while Stakeholder 4 advocates for a combination of educational campaigns, water and waste management, and epidemiological surveillance.

The proposals for improving living conditions in El-Zaouia exhibit both similarities and differences. Stakeholder 3 emphasizes a deep restructuring of the neighbourhood through housing rehabilitation or reconstruction, along with the installation of essential infrastructure such as drainage, sanitation, and access to clean water. Stakeholder 2 underscores the need for awareness campaigns and improvements in local healthcare services, complemented by the development of basic infrastructure. Stakeholder 1 focuses on practical solutions such as waste management and stormwater drainage. Finally, Stakeholder 4 suggests an integrated approach that combines health education, water supply, waste management, and epidemiological monitoring.

Among these proposals, that of Actor 3 seems the most suitable, because it addresses the major structural challenges of the neighbourhood, including housing, sanitation and land regularization, while involving residents in the process. Such an approach would lead to lasting improvements in living conditions. However, to be effective, this solution should be complemented by awareness campaigns (Actors 2 and 4) and rigorous waste management (Actor 1).

Discussion

The results of the questionnaire reveal essential conclusions about the health conditions in the El-Zaouia neighbourhood. This district, which is made up of an informal and a precarious area, suffers from a number of problems linked to inadequate access to drinking water, the absence of a suitable sewerage system and poor waste management. Among the most notable problems are the direct discharge of wastewater into the streets, the accumulation of rubbish in the wadi and on street corners, and recurrent flooding during the winter season, leading to the stagnation of rainwater and contamination of the immediate environment.

These conditions create an environment conducive to the proliferation of diseases that directly affect the health of residents.

Prolonged exposure to contaminated water leads to an upsurge in dermatological diseases (irritation, skin infections), as well as serious gastro-intestinal diseases such as gas-

tro-enteritis, brucellosis and hepatitis A. These diseases are widely described in the scientific literature (WHO, 2019a), which points out that the lack of access to drinking water and good-quality sanitation is a major factor in the spread of water-borne diseases. In addition, the presence of open waste encourages the proliferation of pathogenic vectors, in particular mosquitoes, responsible for malaria and dengue fever, and rodents, carriers of leptospirosis (UN-Habitat, 2021).

Semi-structured interviews with local stakeholders confirm these observations, highlighting the lack of sanitation infrastructure and poor waste management as the main causes of health risks. The district's current buildings are also deemed incapable of withstanding flooding, leaving residents more exposed to water-borne and respiratory diseases. In addition, the overcrowding and lack of ventilation in these homes encourage the rapid spread of respiratory infections and skin diseases, a phenomenon well heralded by National Academies of Sciences, Engineering, and Medicine (2018).

In addition to respiratory infections, the use of solid fuels such as wood and coal for cooking and heating exacerbates health problems including asthma and chronic obstructive pulmonary disease (COPD). Smith et al (2013) emphasise that prolonged exposure to fine particles and carbon monoxide in confined spaces leads to a progressive deterioration in lung function.

In this context, health professionals insist on several essential preventive measures: regular hand washing, limiting exposure to landfill areas, boiling water before consumption, protecting water tanks from contaminants, as well as adequate ventilation of dwellings. In addition, they recommend regular medical check-ups for residents suffering from respiratory diseases, to avoid any deterioration in their state of health (National Academies of Sciences, Engineering, and Medicine, 2018). Facilitated access to healthcare facilities is also necessary. As the WHO (2019) points out, inequalities in access to healthcare services lead to significant differences in life expectancy between rich and poor countries.

International comparisons and success stories

The health challenges faced by the El-Zaouia district are not isolated, and a number of cities around the world have put in place effective strategies to deal with them. Medellín, in Colombia, is a notable example with its Integrated Urban Project (PUI), which has enabled the rehabilitation of precarious urban areas by improving basic infrastructure, rehousing residents and setting up integrated transport systems (AFD, 2014). This approach has improved access to essential services and gradually integrated disadvantaged neighbourhoods into the urban fabric by connecting them to the rest of the city via transport systems. It has also improved quality of life by creating more employment and education opportunities, while reducing crime rates by improving the social environment.

Another example is Antananarivo, Madagascar, with the ‘Lalan'kely’ project, focusing on sanitation and community infrastructure management. This programme includes the creation of drainage networks, waste management and solutions to open up informal areas in order to gradually integrate them into urban planning. The intermunicipal initiative with ‘Fiftama’ also facilitates the coordination of development efforts and the implementation of basic infrastructure (AFD, 2014).

The project has made it possible to significantly improve local amenities and generate jobs through a labour-intensive approach, thereby helping to increase household incomes.

Support for local economic activities has also strengthened community resilience and improved living conditions, illustrating the effectiveness of this approach in gradually integrating precarious neighbourhoods into formal urban dynamics.

Adapting solutions to the El-Zaouia district

Applying these models to El-Zaouia requires improvements to essential infrastructure. First and foremost, it is imperative to ensure reliable access to drinking water and to set up an efficient sewerage system, as emphasised by Sy et al. (2011) in their analysis of precarious neighbourhoods in Mauritania. A rainwater drainage system is also needed to reduce frequent flooding, which encourages the proliferation of water-borne diseases and respiratory infections.

In addition, waste management needs to be optimised, in particular by setting up regular collection points and selective sorting systems to prevent the accumulation of solid waste and the proliferation of pathogenic vectors, as highlighted by UN-Habitat (2020) in its recommendations on urban resilience.

Easier access to healthcare facilities is another fundamental lever for improving living conditions. As indicated by the French Ministry of Health (2021), the creation of participatory health centres and homes improves access to local healthcare in disadvantaged areas. This model has proved effective in several similar contexts in North Africa and sub-Saharan Africa (WHO, 2019b), where the establishment of local medical structures and prevention campaigns has led to a significant improvement in public health indicators.

A participatory approach involving the population in the planning and implementation of solutions is essential to ensure their sustainability (Mebirouk, 2018). Dongo et al (2008) stress the importance of close collaboration between local authorities and residents to ensure greater ownership of interventions. Studies conducted by UN-Habitat (2021) show that community mobilisation boosts the effectiveness of sanitation and healthcare programmes in precarious neighbourhoods.

A combination of infrastructural, health and social measures, inspired by international experience and adapted to specific local conditions, would make it possible to improve living conditions in El-Zaouia over the long term and reduce the health risks faced by residents.

Proposals and recommendations

To address the challenges faced by informal settlements in Tébessa and improve the living conditions of residents in the El-Zaouia neighbourhood, we propose the following measures, in alignment with urban planning guidelines and public stakeholders:

- Demolition of substandard structures: Remove all precarious constructions and replace them with suitable social housing.
- Implementation of essential infrastructure: Establish a wastewater drainage network for all existing buildings and connect them to the municipal system.
- Improvement of basic infrastructure: Develop potable water supply networks and adequate roadways.
- Land regularization: Ensure the legal regularization of all land parcels by providing authenticated property titles.
- Development of a reception site: Create a dedicated reception area within the neighbourhood, equipped with all necessary amenities to ensure a decent standard of living.

These interventions aim to enhance residents' quality of life and provide a healthy and appropriate living environment. To further improve the living conditions in El-Zaouia and curb the spread of diseases, we recommend the following actions:

Demolition of Substandard Housing

Demolish non-rehabilitable structures, particularly those located along the banks of the Oued, while ensuring adequate resettlement to prevent displacement and homelessness. The demolition process should be carried out immediately after the allocation of new housing units.

In-Situ Rehabilitation

The aim of this operation is to improve the living conditions of residents in the district while keeping them there (without displacing or rehousing them in other areas). It comprises a range of interventions, including:

- Building Rehabilitation: Renovate structurally sound buildings to comply with safety and comfort standards.
- Improvement of Road Networks: Widen streets to facilitate waste collection and strategically install collection points, preferably at the neighbourhood entrance.
- Sanitation Networks and Infrastructure: Construct sanitation systems to prevent water stagnation, develop potable water supply systems, and establish storm water drainage networks with enhanced maintenance to mitigate flooding risks.
- Permeable Surfaces and Green Spaces: Use permeable paving materials to absorb rainwater and reduce runoff while integrating green spaces to improve environmental quality and manage storm water.
- Local Healthcare Services: Establish healthcare facilities in proximity to the neighbourhood to ensure more accessible and cost-effective medical care.

Community Consultation

Involving residents in the planning and implementation of projects is essential, as they have in-depth knowledge of their day-to-day environment and the difficulties they encounter. This knowledge is a valuable resource for understanding problems and guiding projects effectively, ensuring that interventions really do meet their needs and ensure the success of the initiatives undertaken. Community participation helps to build trust between citizens and local authorities, creating an environment conducive to effective participation in decision-making.

Implementing the recommendations could face financial, social and political challenges. Financially, insufficient resources require inter-institutional cooperation, as well as the integration of national support and development programmes. Socially, residents' fears about demolition and rehousing require their involvement from the earliest planning stages, accompanied by official guarantees that their rights will be protected. Politically, effective coordination between the various players is essential to avoid delays and ensure coherent implementation, which justifies the creation of a local body responsible for monitoring and consultation (Mebirouk, 2019).

Conclusion

Our study examined the specific health challenges faced by residents of the El-Zaouia neighbourhood, which is characterised by social and environmental vulnerability. The study hypothesised that poor health conditions, such as lack of access to drinking water, inadequate sanitation infrastructure and poor waste management, were conducive to the spread of disease. We adopted a methodology involving analysis of data collected via questionnaires, field observations, and surveys of residents, public stakeholders and housing experts.

The results of our study confirm this hypothesis: the health situation in the El-Zaouia neighbourhood is indeed linked to a high incidence of infectious, dermatological, respiratory and water-borne diseases. These problems are exacerbated by flooding, the stagnation of wastewater and rainwater, precarious building materials, the proliferation of waste through burning, and the lack of access to drinking water, creating an environment conducive to the spread of pathogens.

To improve living conditions in the El-Zaouia district, we have proposed a number of solutions. These include measures inspired by well-established international models, such as those of Medellín in Colombia and Antananarivo in Madagascar. These models emphasise the importance of in situ rehabilitation and consultation with local residents throughout the project's procedures and operations. By implementing these solutions, it is possible to significantly improve the living conditions of residents, break the cycle of poverty and vulnerability, and guarantee a better and safer future for local residents.

However, it is important to note certain limitations of this study. Firstly, the geographical scope of the surveys was restricted to the El-Zaouia neighbourhood, which may limit the generalisability of the results to other neighbourhoods or similar contexts. In addition, data collection was hampered by time and resource constraints, which may have influenced the depth of the information gathered. Finally, the proposed solutions are based on international models which, although effective, require contextual adaptation to be fully relevant in the local context of Tébessa.

To go beyond the limitations identified, it would be relevant to extend the research to other neighbourhoods and to conduct longitudinal studies to assess the impact of the interventions over the long term. In addition, a more detailed analysis of the specific socio-economic and cultural conditions in the area could help refine the proposed solutions and ensure their effectiveness. Ongoing collaboration with residents and local authorities is essential to adapt approaches to the specific needs of the neighbourhood and ensure the sustainability of improvements.

The findings of this research highlight the importance of territorial strategies grounded in empirical data and field observations. These approaches are essential tools for analyzing urban dynamics, prioritizing interventions, and effectively targeting vulnerable populations, particularly by improving their access to services and overall living conditions.

Conflicts of Interest: The authors declare no conflict of interest.

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Field Survey Form

This form is intended for the scientific research titled:

"From the examination to the improvement of sanitary conditions in under-priviliged neighbourhoud : The case of El Zaouia in Tébessa, Algeria"

We kindly ask you to answer the following questions, seriously.

Please check the appropriate box (X):

Demographic data

1. **Gender:** .....
2. **Age:** .....
3. **Level of education:** .....
4. **Profession:** .....
5. **Place of birth:** .....
   ☐ Inside the city ☐ Outside the city
6. Are you the head of the household?
   ☐ Yes ☐ No
7. If no, what is your relationship to the head of the household?
   ☐ Husband ☐ Wife ☐ Uncle ☐ Aunt ☐ Nephew ☐ Niece
   ☐Cousin (male) ☐ Cousin (female) ☐ Other
   If other, please specify: .....
8. **What are the reasons that led you to migrate to the city of Tébessa?**
   ☐ Employement ☐ Housing search ☐ Availability of services in the city ☐ Security

- **If other, please specify:** .....

What is the nature of the land ownership?

☐Purchased ☐Acquired without purchase

Housing conditions

1. **Do you possess a title deed?**
   ☐ Yes ☐ No

- If yes, is it a:
  ☐ Legal deed ☐ Customary deed

2. **What is the surface area of your house?** ..... m²
3. **How many floors does it have? .....**
4. **What are the construction materials of your house?**

- **Roof:**
  ☐ Metal sheets ☐ Fiber cement ☐ Reinforced concrete
- **Walls:**
  ☐ Brick ☐ Cinder block ☐ Reinforced concrete

5. **What is the condition of your home?**
   ☐ Poor ☐Average ☐ Good

- If the condition is poor, what are the causes?
  .....
  .....

6. **How many rooms does your home have?**
   ☐ More than 5 ☐ 5 ☐ 4 ☐ 3 ☐Fewerthan 3
7. **Do you have a kitchen in your house?**
   ☐ Yes ☐ No

Public health conditions

1. Is your house located near a river (Oued)?

☐ Yes ☐ No

- If yes, has it ever been at risk of flooding?
  ☐ Yes ☐ No
- If yes, how often do floods occur approximately?
  ☐ Rare (every 5 years or more)
  ☐ Intermittent (every 2–4 years)
  ☐ Frequent (annually or more)

2. Have floods caused material or human damage?

☐ Yes ☐ No

3. Are there flood prevention measures in the neighborhood (barriers, water drainage channels)?

☐ Yes ☐ No

- If yes, are they effective in reducing floods?
  ☐ Yes ☐ No

4. Is your home connected to the drinking water network?

☐ Yes ☐ No

- If no, what is your water supply source?
  ☐ Neighborss ☐ Privater water tanks ☐Other

5. Is your home connected to the sanitation network?

☐ Yes ☐ No

6. How is wastewater disposed of?

☐ Into the sewers ☐ Into the Oued ☐ Other

7. Where do you dispose of your waste dumping?

☐ In designated areas ☐Into the Oued ☐ Other

8. Are there healthcare services available near your neighborhood?

☐ Yes ☐ No

Health impacts

1. Have you or any family member suffered from waterborne diseases ?

☐ Yes ☐ No

- If yes, what are these illnesses? .....

2. Have you or any family member suffered from diseases related to wastewater?

☐ Yes ☐ No

- If yes, what are these illnesses? .....

3. Have you or any family member suffered from diseases related to poor waste management?

☐ Yes ☐ No

- If yes, what are these illnesses? .....

In your opinion, what are the projects this neighbourhood needs?

.....

.....

Thank you for your attention. Please accept our kindest regards.