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Revisiting and Recalibrating the Impact of Legionnaires' Disease on Maltese Public Health Awareness and Preparedness

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ABSTRACT

Our study was a return to the *Maltese Annual Notifiable Infectious Disease Reports: 2010-2024* (Maltese DataBase) to revisit the gaps, voids, and misclassification flaws we encountered with our initial examination of the Maltese DataBase, focusing on the stats (incidents and deaths) associated with Legionnaires' Disease, a respiratory condition.

Specifically, we sought to rewrite our initial examination of the Maltese DataBase and to recalibrate our initial determination (IBM/SPSS) of the potential (current and emerging) impact of Legionnaires' Disease on the public health of the Maltese population. Latent and foreboding trends in the Maltese DataBase were unchanged, remaining worrisome.

Our initial determination (with Central Limit Theory) yielded a Maltese Chance of Death at 3.9%-12.4% from Legionnaires' Disease, covering an initial sample of 160 incidents and 13 deaths during 2010-2022.

Revisiting the Maltese DataBase with acute curiosity, we began a systematic review by reclarifying content and retracking, reverifying, and unraveling data to reassure validity and accuracy of our initial study, plus the consistency of posted incidents and deaths.

We repeated our IBM/SPSS/Central Limit Theory analysis using new data to reassure the integrity and validity of our research. Recalibration revealed an updated Chance of Death at 1.83%-11.1%, using a sample set of 108 incidents and 7 deaths during 2010-2022.

We present, also, suggestions for improving the management, standardization, and auditing of the *Maltese Annual Notifiable Infectious Disease Reports* – which is a vital resource for promoting awareness and readiness, essential for the future of Malta. A strategic step is to consider adopting and installing an AI tool to manage and operate the Maltese Database.

KEY WORDS

Legionellosis, Legionnaires' Disease, Chance of Death, Central Limit Theory, Malta, and *Maltese Annual Notifiable Infectious Disease Reports.*

BACKGROUND

The term "legionellosis" depicts the respiratory illness in humans brought on by bacteria of the genus *Legionella* – natural pathogens of environmentally free-living eukaryotes(1).

These bacteria were first discovered after isolation following a mass outbreak in 1976 of an atypical pneumonia at an American Legion Convention in Philadelphia (USA)(2,3). While Legionella outbreaks are not uncommon, Malta is also without an exemption(4,5).

Legionellosis includes both a potentially fatal form of human pneumonia, aptly coined the "Legionnaires' Disease," which primarily affects weak elderly and immunocompromised individuals, and a second form, Pontiac Fever, a disease that is self-limiting in nature, and usually does not progress to deadly pneumonia(6). Both have attracted extensive research.

Transmission of *Legionella Bacteria* occurs primarily via aerosol inhalation in a clustered, contaminated environment, while Legionnaires' Disease has become closely linked to and associated with usual and day-to-day use of man-made water systems: hot tubs, swimming pools, public fountains, and especially all types of water cooling towers. All examples are prime sources of aerosols(7,8,9,10,11). With these structures, Legionnaires' Disease is awaiting the opportunity to be transmitted via aerosols(12).

INTRODUCTION: REVISITING

Our study team was attracted to the *Maltese Annual Notifiable Infectious Disease Reports* to learn more about the state of Legionnaires' Disease in Malta and to assess its potential impacts on public health, especially with the expanding demands of booming tourism on a tight island. We sought to determine if Legionnaires' Disease was a genuine threat(13,14) – while continuing our opening examination of the Maltese Database and extending our work to the neighboring islands of Sicily and Cyprus for an expanded view of Legionella(15).

Incidents and the associated deaths with Legionnaires' Diseases are recorded in the *Maltese Annual Notifiable Infectious Disease Reports,* a public document. Our initial examination of the Maltese DataBase was designed to use the Legionella information to assess the potential impact (current and long-term) of Legionnaires' Disease on the public health of Malta(16,17). Our metric was a Chance of Death from Legionnaires' Disease, calculated using IBM/SPSS.

We struggled with the non-uniformity of the Maltese DataBase. Concerned about the run of inconsistences, gaps, and misclassification encountered, our curiosity drove us to revisit our initial research study. Our recalibration was reassuring for incidents, but quite surprising for associated deaths, as summarized in Table 1.

BACKGROUND: RECALIBRATING

Our revisit of the *Maltese Annual Notifiable Infectious Disease Reports* was methodical, systematic, and yielded a recalibrated combination of the total incidents and deaths, plus a revised Chance of Death, associated with Legionnaires' Disease in Malta. The number of incidents (total of actual and unofficial) remained unchanged – however, the number of associated deaths was dramatically different with recalibration. Also, a rapid spike in incidents remained ominous and concerning, as revealed in Figures 1 and 2.

An updated comparison of the initial and recalibrated data for incidents and associated death due to Legionnaires' Disease, all public information, is summarized in Table 1.

We attribute the stark difference in deaths to better clarity and our deciphering of posted stats, which we offer, was a judicious separation of usual pneumonia versus difficult and fuzzy to diagnose (without final lab confirmation) Legionnaires' Disease.

Using an updated combination of incidents and deaths, our recalibration yielded a current Chance of Deaths from Legionnaires' Disease at 1.83% to 11.13%. In comparison, initial Chance of Death was 3.9% to 12.4 %. This difference is reasonable – yet cautionary.

We are quite confident of our extractions with our revisit and recalibration. The Maltese DataBase is an invaluable tool for enhancing surveillance, awareness, and preparedness for timely decision-making to ensure the sustainability of the public health environment for the Maltese citizenry(17,18).

Recalibration emphasized a deeper look at consistency, clarity, plus data classification with the Maltese DataBase. We are confident our revisit was fair and balanced, plus accurate. Our effort revealed a balance with Chance of Death. However, the trend in incidents remained foreboding and troublesome. The spike of incidents was obvious in Figure I – while sustained in Figure 2.

The spike in recent years (2022-2025) urges caution and attention to surveillance and monitoring, especially potential water generating aerosol sites and sources.

Table 1: Data Table for Legionella Incidents and Deaths in Malta*

	INITIAL ASSESSMENT[a] (8 March 2026)		RECALCULATION[a] (13 July 2026)	
YEAR	**Incidents**	**Deaths**	**Incidents**	**Deaths**
2010	12	7	11	1
2011	13	0	13	0
2012	4	0	4	0
2013	6	1	6	0
2014	7	1	7	1
2015	6	1	6	1
2016	8	1	8	1
2017	11	2	11	2
2018	12	0	12	0
2019	5	1	5	1
2020	16	0	16	0
2021	8	0	8	--
2022	9	0	9	0
2023[b]	13	n/a	13	n/a
2024[b]	30	n/a	30	n/a
2025[b]	24	n/a--	24	n/a
TOTALS	184	13	184	7

*Source: *Maltese Annual Notifiable Infectious Disease Reports (2010-2024).* Malta Health Promotion & Disease Prevention Directorate.

[a]IBM / SPSS – Professor Liberato Camilleri, University of Malta.

[b]Unofficial Data – Layla Rahimpour, University of Malta.

IBM / SPSS COMPARATIVE ANALYSIS

Our new analysis of the data extracted from the *Maltese Annual Notifiable Infectious Disease Reports* reapplied the Central Limit Theory for clarity and insight(16,17).

Let n be the total number of cases of a rare disease between 2010 and 2024 and let X be the number of deaths from this disease. The sample proportion $\bar{p}$ of deaths is given by:

$$\bar{p} = X/n$$

The Central Limit Theorem states that the random variable *z* has an approximate standard normal distribution where

$$z = \frac{\bar{p} - p}{\sqrt{\frac{p(1-p)}{n}}}$$

where *p* is the unknown population proportion.

In order to test whether the unknown population proportion *p* is equal to a given proportion p_o we specify the following hypotheses:

$$H_0 : p = p_o$$
$$H_1 : p \neq p_o$$

If we test for H_0, the variable z becomes $z = \frac{\bar{p} - p_o}{\sqrt{\frac{p_o(1-p_o)}{n}}}$ since $p = p_o$.

Assuming a 0.05 level of significance, H_0 is accepted accordingly if the z-score lies between 1.96 and 1.96 and H_1 is accepted if the z-score is smaller than -1.96 or exceeds 1.96.

An alternative method to make inference (generalization) about the unknown population proportion *p*, is to compute the 95% confidence limits for *p* using the sample proportion $\bar{p}$, which is given by:

$$\bar{p} \pm 1.96\sqrt{\frac{p(1-p)}{n}}$$

Since the population proportion *p* is unknown, we replace it by its unbiased estimator $\bar{p}$.

IBM / SPSS COMPARATIVE ANALYSIS

Proportion of Deaths from Legionnaires' Disease

Throughout the period 2010-2025 there were 183 Maltese individuals who contracted the Legionnaires' Disease; however, the number of deaths (X) caused by this disease was only recorded for 12 years (2010-2022). Throughout these 12 years, 108 Maltese individuals contracted the Legionnaires' Disease and 7 died. The sample proportion is (See Table 1 for data.):

$$\bar{p} = \frac{X}{n} = \frac{7}{108} = 0.0648 = 6.48\%$$

The 95% confidence limits of the actual proportion of individuals who died after contracting the Legionnaires' Disease is:

$$\bar{p} \pm 1.96\sqrt{\frac{p(1-p)}{n}} = 0.0648 \pm 1.96\sqrt{\frac{(0.0648)(0.9352)}{108}} = 0.0648 \pm 0.0237$$

If we had to consider a wider range of years, we are 95% confident that the actual proportion of individuals who died or will die in the future after contracting Legionnaires' Disease lies between 0.0183 (1.83%) and 0.1113 (11.13%).

It is estimated that in the world around 10% of individuals who contract Legionnaires' Disease die. To determine whether Malta's proportion of deaths from Legionnaires' Disease is comparable to 10% (0.1), we specify the following hypotheses:

$$H_0 : p = 0.1$$
$$H_1 : p \neq 0.1$$

So

$$z = \frac{\bar{p} - p_o}{\sqrt{\frac{p_o(1 - p_o)}{n}}} = \frac{0.0648 - 0.1}{\sqrt{\frac{(0.1)(0.9)}{108}}} = \frac{-0.0352}{0.0289} = -1.2180$$

Since the z-score (-1.218) lies between -1.96 and 1.96 we accept H_0, which implies that the proportion of deaths (6.48%) of Maltese individuals from Legionnaires' disease is comparable to the international proportion of deaths (10%). In other words, the two proportions do not vary significantly.

Table 2: Comparative Chance of Death for Malta from Legionnaires' Disease*

INITIAL ASSESSMENT[a] (8 March 2026)	versus RECALCULATION[a] (13 July 2026)
3.9 to 12.4 %	1.83 to 11.13%

*Data Source: *Maltese Annual Notifiable Infectious Disease Reports (2010-2024):* Malta Health Promotion & Disease Prevention Directorate.

[a]IBM / SPSS – Professor Liberato Camilleri, University of Malta.

DISCUSSION: RECOMMENDATIONS

Operational and Strategic

Our initial visit and revisit of the *Maltese Annual Notifiable Infectious Disease Reports* has prompted us to recommend the following actions by the Malta Health Promotion & Disease Prevention Directorate to strengthen and safeguard the integrity and reliability of the management and operations of the Maltese Database, serving as the undisputable resource of accurate information for planning and timely decision-making by the public and private leadership with Legionella Outbreaks(18,19). Consistency of disease data classification, therefore, is a must hallmark to be achieved(20).

Our essential operational recommendations are pragmatic, distinct, plus doable:

> Implement a combined management information system (MIS)to monitor the collecting, recording, and safekeeping of infectious disease data.

> Implement a standardized nomenclature with distinct classification codes.

> Hire a certified public auditor to schedule and conduct a thorough annual independent management system performance audit.

> Coordinate and provide annual training seminars for those responsible for the management, operation, and use of the Maltese DataBase.

Moreover, our strategic recommendation is to implement an AI system to manage and to operate the Maltese DataBase, installing a monitored dashboard to ensure security.

An added benefit of a quality AI system is providing action-accessible information to help enhance the monitoring and enforcement of cooling towers with critical infrastructure value, such as hospitals water systems and water treatment plants(21,22).

SPIKE SPECTRA

Figure 1. LEGIONELLA SPIKE – Initial Assessment

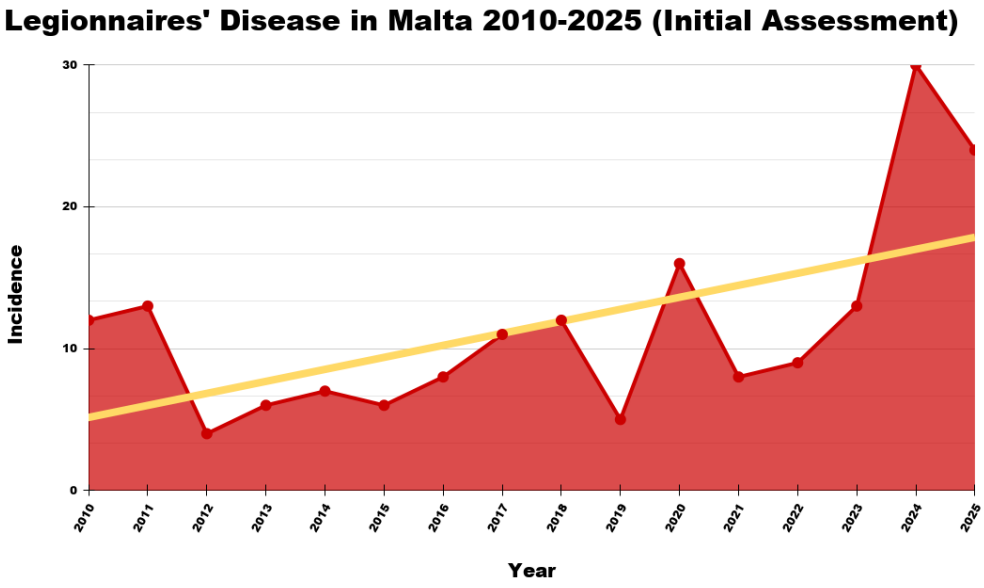
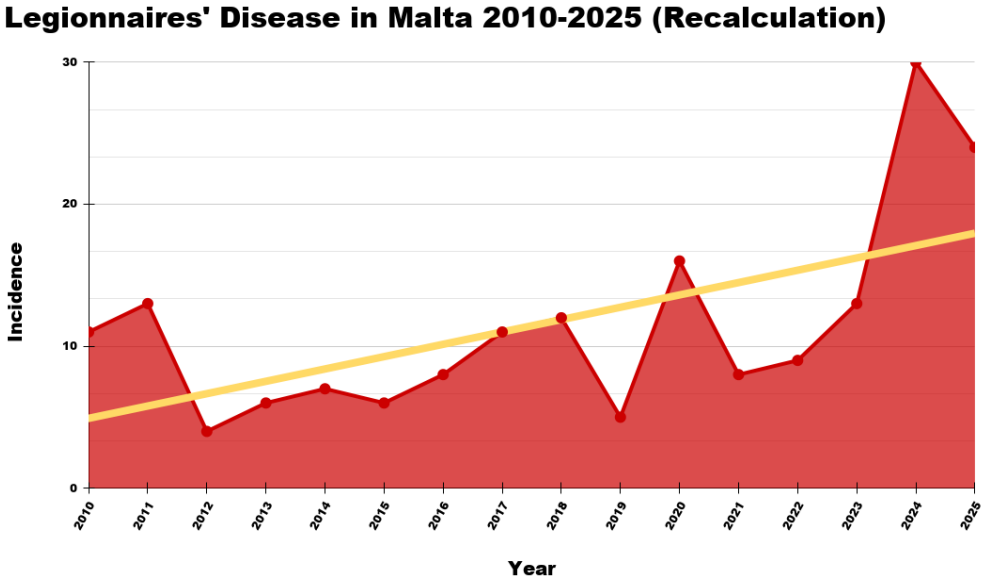


Figure 2. LEGIONELLA SPIKE – Recalculation



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RESOURCES - Continued

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DISCLOSURES

DECLARATION OF CONFLICTING INTEREST

Authors declare no competing issues nor Conflict of Interest with this project or any other conflict with the content of the manuscript. All agree to journal submission.

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DATA AVAILABILITY

All data for our research study are presented within this article and are readily accessible to any interested person from the Corresponding Author with a written or electronic request.

The *Maltese Annual Notifiable Infectious Disease Reports (2010-2024)* are available at

file:///E:/2026P%20%20%20HPDP%20--%20Ten%20Year%20List%20-%20Annual%20Tables/Annual%20Tables%20_%20HPDP.htm

ETHICAL APPROVAL & INFORMED CONSENT STATEMENT

Authors understand no approval or authorization from an Institutional Review Board was required according to the nature and focus of our research project on data.

TRANSPARENCY

Authors volunteer that *chat GPT*, or any equivalent AI program, was not used to generate data or text to support our research and was not used to draft or embellish our manuscript.

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AUTHORS: CONTRIBUTIONS

▪ Layla Rahimpour:	Conceptualization, Investigation, and Formulation, plus Drafting and Editing Final Manuscript.
▪ Liberato Camilleri:	Data Management, Methodology, Data Analysis, plus Reviewing / Editing Final Manuscript.
▪ Neville Calleja	Co-Reviewing Methodology and Investigation, plus Editing Outline and Final manuscript.
▪ Charmaine Gauci	Co-Reviewing Methodology and Investigation, plus Editing Outline and Final Manuscript.
▪ Lee Presley Gary, Jr.:	Co-Conceptualization, Resources, Visualization, plus Writing, Editing, and Finalizing Manuscript.

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- Lee P. Gary, Jr.: Lee is Visiting Fulbright Research Scholar at the University of Malta, and he is the Director of the Maltese Legionella Project. Previously, he was a Visiting Fulbright Fellow with the School of Public Health at the University of Makeni(UNIMAK) in Sierra Leone for 2025 and will return to UNIMAK for the 2027 Spring Session.

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