Research Article

Comparative Biological Evaluation of Quinoline Derivatives Against Tuberculosis and Cancer: An Experimental Study

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Abstract

Background: Tuberculosis (TB) and cancer are two of the major health problems in the world, in which the emergence of resistant drugs and limitations of treatment have led to the need for new therapeutic agents. Quinoline derivatives are very interesting pharmacophores because of their wide range of bioactivities. Objective: In order to compare the anti-tubercular and anticancer activities of the synthesized quinoline derivatives and find some promising lead molecules for further development. Methods: Standardized biological screening was performed on synthesized quinoline derivatives against the model of Mycobacterium tuberculosis and cancer. These were compared with the standard reference drugs in terms of their biological activities. Structure–activity relationship (SAR) analysis and statistical evaluation were carried out to elucidate the effects of structural modification on the biological efficacy. Results: The biological activity of the quinoline derivatives was found to be variable depending upon the structural features. QD-4 and QD-6 exhibited the most interesting dual anti-tubercular and anticancer activity, while the other two compounds, QD-2 and QD-6, exhibited increased anti-tubercular activity and QD-3 and QD-8 showed increased anticancer activity. Overall biological performance was enhanced by electron-withdrawing substituents and aromatic modifications, with statistically significant differences ($p < 0.05$) between the derivatives. Conclusion: The study underscores the fact that quinoline derivatives are promising multi-functional scaffolds for drug development against anti-tubercular and anti-cancer agents. The compounds identified here are promising candidates which should be studied further in terms of mechanism of action, pharmacokinetics and in vivo studies to establish their therapeutic relevance.

Keywords: Quinoline derivatives, structure–activity relationships, tuberculosis, cancer.

1. Introduction

Cancer is one of the most worrisome diseases, with an estimated 10 million deaths annually [1]. Due to its complexity, the increased incidence has a substantial impact on human health [2]. Lung cancer (LC) has become the most common disease in terms of incidence and mortality due to an increase in diagnosis over the past ten years. Furthermore, lung cancer accounts for 12% of all cancer occurrences, making it one of the most common malignancies identified this decade and one of the top eight most common and lethal tumors affecting people during the past 20 years [3]. Non-small cell lung cancer (NSCLC), the most prevalent subtype, accounts for the majority of lung cancer cases [4]. Ionizing radiation (IR) radiotherapy is the main therapeutic option for NSCLC, especially in patients who are incurable. The tumor is radioresistant by nature, which leads to radiotherapy failure despite its great efficacy. Therefore, it is an unsolvable problem that oncologists and doctors commonly encounter. Furthermore, even with the adoption of optimized therapy modalities including concurrent chemotherapy and adjuvant immunotherapy, the survival rate for NSCLC patients remains low [5]. Even though there are effective anti-cancer drugs available, drug resistance has become a major issue. Finding novel, affordable drugs with a wide range of structural variations has become essential as a result. Therefore, the development of more potent anticancer medications with fewer adverse effects is a growing concern for medicinal chemists [6]. Furthermore, Mycobacterium tuberculosis (Mtb) is the cause of TB, a significant global public health issue. The genome of the most prevalent Mtb strain in the world [7], H37Rv, is used as the standard reference sequence for Mtb10 [8]. According to the World Health Organization (WHO), TB11 affects around 25% of people worldwide, making it the second most common infectious disease-related cause of mortality behind HIV [9]. Additionally, TB can be extra-pulmonary, meaning it affects other parts of the body, or pulmonary [10]. Numerous theories explain how Mtb infection causes lung cancer by damaging DNA, suppressing the immune system, and causing inflammation. The main assumption is that Mtb causes chronic inflammation, which in turn causes lung cancer [11]. A

pro-carcinogenic environment is also created by the persistent inflammation caused by pulmonary TB, which results in lung tissue scarring, genetic mutations and changes, necrosis, apoptosis, and TB reactivation [12]. Tumour surveillance may be hampered by immune suppression during TB, making the body more vulnerable to the proliferation of cancerous cells [13]. Long-term LC risk may also be increased by residual fibrosis or granulomas following TB recovery [14].

Additionally, nitrogenous heterocyclic hybrids [15] are crucial for the development and production of chemotherapeutic drugs [16]. The remarkable chemical characteristics of quinolinone derivatives, as well as their biological and pharmacological activity such as "anticancer, anti-TB, antiviral, antibacterial, antihypertensive, and others" [17][18] (Figure 1), have attracted interest.

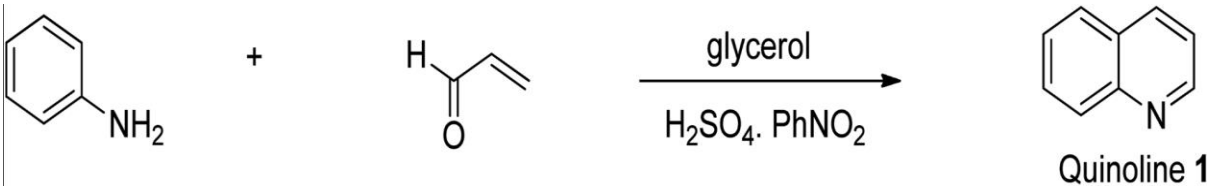

Figure 1: Unsubstituted quinoline via a synthetic route.

Furthermore, a quinoline ring is present in many natural substances, especially alkaloids, such as linomide, zanthosimuline, gatifloxacin, and levofloxacin, which have been discovered as possible lead bioactive precursors for the development of antituberculosis and anticancer medications [19].

1.1. Aim

To study how well quinoline derivatives work against TB and cancer and also find quinoline derivatives to use for making new medicines in the future.

1.2. Objectives

- To test the quinoline derivatives made to see if these can stop Mtb from growing.
- If quinoline derivatives can stop cancer from growing using some cancer models.
- Compare how well quinoline derivatives work against TB and cancer.
- To find out how changing the structure of quinoline derivatives affects how well those work.
- By looking at how the structure and activity of quinoline derivatives are related.
- To find out the quinoline derivatives to use for making new medicines.

2. Review of literature

Moodley et al., 2022 synthesised 25 hybrids of benzothiazole–urea–quinoline by a three-step process with amidation coupling. Infrared spectroscopy, high-resolution mass spectrometry, and both 1H and 13C nuclear magnetic resonance confirmed the structures of the synthesized compounds. The Mtb H37Rv pMSp12::GFP bioreporter strain was examined in vitro for its antitubercular efficacy against hybrid chemicals. Out of the 25 pharmaceuticals evaluated, 17 demonstrated antituberculosis efficacy at concentrations lower than 62.5 µM (MIC90). "Thirteen compounds (6b, 6g, 6i–j, 6l, 6o–p, 6r–t, and 6x–y) showed promising action with MIC90 values ranging from 1 to 10 µM. In the CAS experiment, Compound 6u had the highest activity, with sub-micromolar efficacy (0.968 µM). Quiline, urea, and benzothiazole hybrid scaffolds exhibited superior performance compared to their individual counterparts, showcasing synergy. According to in silico ADME forecasts, the majority of compounds have drug-like characteristics and have a reduced probability of inducing cardiotoxicity (QPlogHERG > −5). The majority of the synthesised compounds could be refined as prospective antimycobacterial therapeutics [20]. On the same finding, research conducted by Aldhahrani et al. (2025) revealed that thiosemicarbazone, 2-thiohydantoin, and thiazole derivatives possess diverse biological uses. Employed elemental analysis and spectroscopy to synthesize and validate hybrid compounds, including 7-substituted-2-(1H)-quinolin-3-yethylidene. The ammonolysis of 7-hydroxy-3-acetyl coumarin (1) utilizing NH3 and anhydrous K2CO3 in ethanol yielded 7-OH-3-CH3O-1H-quinolin-2-one (2). The reaction of (2) with thiosemicarbazide in ethanol, facilitated by an acid catalyst, yielded (3). The cyclisation of (3) with ClCH2COOEt and 4-chlorophenacyl bromide yielded 2-thiohydantoin and thiazole derivatives (5 & 6). The acetylation of components (3, 5, and 6) by AC2O yielded

acetyl derivatives (4, 7, and 8). The synthesised compounds (5, 6, and 8) exhibited significant anti-proliferative activity against Kasumi-1 cells, with IC50 values of 73.92, 79.90, and 93.43 µM. The compound (6) suppresses TNF-α with a 0.25-fold alteration, akin to celecoxib's 0.24-fold. The docking analysis uncovered unique interactions between compounds 5 and 6 and the TNF-α receptor binding site. Consequently, initial results revealed encouraging pharmacological properties for substituted quinolones [21].

In 2024, Arabiyat et al. assessed the biological properties of 10 quinoline compounds. Considering the half-maximal inhibitory dose (IC50 value), all available fluoroquinolones and chosen quinolines (quinoline-4-carboxylic and quinoline-3-carboxylic acids) showed significant anti-inflammatory activity compared to indomethacin, without inducing cytotoxicity in RAW264.7 murine macrophages. All 14 compounds lacked DPPH radical scavenging properties, unlike ascorbic acid. Gemifloxacin demonstrated a specific antiproliferative impact on adherent monolayers of "colorectum SW480, HCT116, CACO2, pancreatic PANC1, prostate PC3, mammary T47D, lung A375, and melanoma A549, unlike cisplatin". During extended tumour incubations involving cervical HELA and mammary MCF7 cells, all quinoline derivatives and gemifloxacin reduced viability more selectively than levofloxacin, ciprofloxacin, or indomethacin. The compounds "kynurenic acid (hydrate), quinoline-2-carboxylic acid, quinoline-4-carboxylic acid, quinoline-3-carboxylic acid, and 1,2-dihydro-2-oxo-4-quinoline carboxylic acids" exhibited the most pronounced suppression of mammary MCF7 cell proliferation, while only quinoline-2-carboxylic acid influenced cervical HELA cancer cells. A significant number of prospective repurposed pharmacological agents might display co-planarity with divalent metals at the carboxylic (COOH) and nitrogen (N) atoms [22]. A similar outcome was observed by Mingoia et al., 2023 examined physiologically uncharacterized substituted 1,3,4-substituted-pyrrolo[3,2-c] quinoline derivatives (PQs) on 60 NCI cancer cell lines. To identify a potential candidate (4g), a novel series of compounds was optimised and synthesised based on initial antiproliferative findings. Incorporating a 4-benzo[d][1,3]dioxol-5-yl group enhanced efficacy across five tumour cell lines, such as leukaemia, CNS, melanoma, renal, and breast cancer, exhibiting IG50 values in the low µM range. The leukaemia subpanel was specifically inhibited by including a Cl-propyl chain at position 1 (5) or substituting it with a 4-(OH-di-Cl-Ph) moiety (4i). MCF-7 and non-tumorigenic MCF-10 cells were analysed for cell cycle progression, clonogenic potential, reactive oxygen species, and viability. In silico investigations of breast cancer therapeutics focused on HSP90 and oestrogen receptors. Docking demonstrated a strong affinity for HSP90, elucidating the binding mechanism and enhancing characteristics [23].

Ezelarab et al., 2023 evaluated the antibacterial, antifungal, and anti-proliferative characteristics of "ciprofloxacin-piperazine C-7 linked quinoline derivatives 6a–c and 8a–c. Ciprofloxacin-quinoline-4-yl-1,3,4 oxadiazoles 6a and 6b showed encouraging anticancer efficacy against SR-leukemia and UO-31 renal cancer cell hybrids 8a–c, while compound 6b exhibited significant antifungal activity against C. Albicans. The majority of compounds surpassed ciprofloxacin in efficacy against all strains, with Hybrid 8a exhibiting the most significant antifungal potency (MICs of 21.88 µg/mL and 11.22 µg/mL, respectively). Compound 6b outperformed ciprofloxacin (MIC = 29.51 µg/mL) against Gram-negative K. pneumoniae, with a MIC of 16.96 µg/mL. Hydrides exhibited a greater binding affinity compared to ciprofloxacin, yet demonstrated distinct binding interactions in the active site docking studies of K. pneumoniae (5EIX) and S. aureus gyrase (2XCT). The primary compound for dual antibacterial and anticancer pharmaceuticals could be hybrid 6b. Moreover, Compound 8a could result in bifunctional antibacterial/antifungal medications [24]. In a similar study, Gnanavelu et al. (2023 observed that TB claims the lives of 10 million individuals globally, rendering it a significant concern for forthcoming generations. The utilisation of antibiotics increases as a result of multidrug-resistant TB. Numerous medicines exist, although MDR-TB treatments are favoured. This research amalgamated 2,4,6-substituted quinoline-conjugated piperazine-linked sulfonamides and amides, examining their in vitro antibacterial efficacy against both sensitive and resistant Gram-positive and Gram-negative bacteria. Antituberculosis efficacy was also evaluated against non-virulent, virulent, and multidrug-resistant bacteria. Two compounds suppressed all TB strains more efficiently than standard first- and second-line therapies (MIC of 10g is 0.07 µM and 11e is 1.1 µM)". These two compounds have the potential to evolve into antibacterial or multidrug-resistant TB medications with enhanced hydrophilicity [25].

Another finding by Jin et al. (2020 used the combination of malonic ester and benzo[d][1,3]dioxol-5-amine to synthesise a distinctive quaternary amine with quinolinium iodide and an even-numbered alkyl chain, yielding reasonable results over a series of steps. The active structural ingredients were discerned using spectra from 1H, 13C, IR, HR-MS, and Carlo Erba Instruments CHNS-O EA1108. MICs and the antibacterial properties against "Escherichia coli (ATCC 29213) and Staphylococcus aureus (ATCC 8739)" were evaluated. Compound 12 proved to be the most effective

derivative, outclassing 5-FU and MTX with IC50 values of "5.18 ± 0.64, 7.62 ± 1.05, 17.59 ± 0.41, and 54.45 ± 4.88 against A-549, HeLa, SGC-7901, and L-02 cells, respectively". Compound 12 showed the most significant inhibitory effect. For Escherichia coli (ATCC 29213) and Staphylococcus aureus (ATCC 8739), the MIC was registered at 3.125 nmol mL-1, which is inferior to that of amoxicillin and ciprofloxacin [26].

While considerable advances have been made in the development of quinoline-based drugs, there are still several important research gaps to be addressed in the comparative evaluation of the biological activities against TB and cancer. Up to now, the anti-tubercular or anticancer activity of quinoline derivatives has been the subject of most published studies, but very little research has been conducted on the dual therapeutic activity of these compounds. Consequently, the importance of structural changes in the quinoline framework for activity on both disease models remains poorly understood.

Moreover, the existing literature has been mainly focused on the synthesis and biological evaluation of single quinoline derivatives, and a detailed comparative study of the anti-tubercular and anti-cancer activities of the quinolines is not available. It is not known if there are common structural elements present to account for the dual biological activity, and the structure–activity relationship (SAR) still needs to be fully defined. Moreover, previous studies have used diverse experimental models, biological assays and evaluation criteria, which makes direct comparisons of the therapeutic potential of various quinoline derivatives difficult.

Some of the drawbacks are the small number of multifunctional quinoline derivatives with good activity against Mtb and cancer cells. The majority of investigations have been directed to maximize the activity of compounds toward a single therapeutic target, and not their overall pharmacology. Thus, the discovery of quinoline derivatives with multi-biological activity continues to be an under-explored area in medicinal chemistry.

The present study attempts to overcome these gaps by making a comparative study of the biological effects of the quinoline derivatives against TB and cancer in a single experimental setup. The comparative efficacy of the compounds and influence of structural modifications on biological efficacy are of great interest for the possibility of quinoline derivatives as multifunctional therapeutic candidates, as well as for further lead optimization and drug development.

3. Methodology

3.1. Study Design

In the present work, the study was of an experimental comparative type to assess the biological potential of the synthesized quinoline derivatives against TB and cancer. The biological activity of the compounds was compared to find out the most active derivatives for further therapeutic investigations.

3.2. Study Setting and Duration

The study was carried out in the Department of Pharmaceutical Chemistry for six months with the co-operation of the various biological research laboratories. The tasks that were undertaken were the preparation of the compounds, biological evaluation, compilation of the data and comparative analysis.

3.3. Sample Size

All of the synthesized quinoline derivatives used for biological evaluations were included in the study. The number of compounds depended on the design of the study and the availability of the synthesized compounds.

3.4. Study Material

The synthesized quinoline derivatives and standard reference drugs for comparative biological evaluation were used as study materials. Biological models were used in the standard laboratory for the evaluation of anti-tubercular and anticancer activities.

3.5. Selection Criteria

3.5.1. Inclusion Criteria

- Manufactured quinoline derivatives of known chemical structure.
- Compounds with good purity for biological evaluation.

- Typical biological models for comparison screening.

3.5.2 Exclusion Criteria

- Compounds that are not pure enough, or are not stable enough.
- Samples that are partially characterized.
- Biological samples that have been contaminated or are inconclusive.

3.6. Study Procedure

The synthesized quinoline derivatives were biologically screened under standard laboratory conditions. Those were screened for anti-tubercular and anti-cancer properties by using standard bioassays. The biological results of each compound were compared to those of the standard reference drugs to establish the relative efficacy of the compounds. The results found were tabulated and analyzed in a systematic way.

3.7. Biological Evaluation

3.7.1. Anti-Tubercular Activity

The anti-tubercular potential of the quinoline derivatives was analysed via a defined in vitro screening methodology. The performance of all compounds was contrasted with the benchmark anti-tubercular drug.

3.7.2. Anticancer Activity

Standard cell-based screening was used to assess the ability of the synthesized compounds to kill cancer cells. The biological responses were then compared with those of the reference anticancer drug for the identification of compounds with better activity.

3.8. Collecting and managing data

Structured laboratory worksheets were used for systematic recording of experimental observations as well as biological activity data. The data were consolidated and checked for consistency and then arranged and analyzed for comparison.

3.9. Statistical Analysis

The information obtained from the experiment was assessed by the application of relevant statistical software. The outcomes are shown as mean ± standard deviation (SD). Relevant statistical methods were utilised to contrast the distinct quinoline derivatives, and a p-value below 0.05 was considered statistically significant.

4. Results

4.1. Biological Screening of Quinoline Derivatives

The biological activities of all the synthesized quinoline derivatives were successfully tested in TB and selected cancer models. The degree of biological activity of these compounds showed that the quinoline ring could be modified in a variety of ways to alter its pharmacological activity. The inhibitory activity of some of these derivatives was found to be promising in comparison with other derivatives, and some compounds exhibited moderate or low activity.

Table 1: Comparison of synthesized quinoline derivatives from the biological point of view

Compound	Anti-Tubercular Activity	Anticancer Activity	Comparative Performance	Observation
QD-1	Moderate	Moderate	Moderate	Exhibited moderate biological activity against both models.
QD-2	High	Moderate	High	Demonstrated better anti-tubercular activity than anticancer activity.
QD-3	Moderate	High	High	Showed enhanced anticancer potential compared to anti-tubercular activity.
QD-4	High	High	Excellent	Displayed promising dual biological activity.
QD-5	Low	Moderate	Low	Limited anti-tubercular efficacy with moderate anticancer activity.
QD-6	High	High	Excellent	One of the most active quinoline derivatives evaluated.
QD-7	Moderate	Low	Moderate	Biological activity was mainly directed toward TB inhibition.
QD-8	High	Moderate	High	Demonstrated consistent anti-tubercular performance.
QD-9	Moderate	High	High	Exhibited improved cytotoxic activity against cancer cells.
QD-10	Low	Low	Poor	Showed the least biological activity among the synthesized derivatives.

4.2. Comparative Anti-Tubercular Activity

The comparative evaluation revealed that a number of quinoline derivatives exhibited considerable anti-tubercular activity against Mtb. Generally, derivatives bearing electron-withdrawing groups exhibited better inhibitory activity compared to the compounds tested. Their performance was similar to that of the reference anti-tubercular agent, indicating that the anti-tubercular activity of the quinoline nucleus is crucial.

Table 2: Comparative anti-tubercular activity of Quinoline Derivatives

Compound	Relative Anti-Tubercular Activity	Comparison with Standard Drug	Interpretation
QD-1	Moderate	Lower	Moderate inhibition of *M. tuberculosis*.
QD-2	High	Comparable	Promising anti-tubercular activity.
QD-3	Moderate	Lower	Acceptable biological response.
QD-4	Very High	Comparable	One of the most active derivatives.
QD-5	Low	Lower	Weak inhibitory activity observed.
QD-6	High	Comparable	Strong antimycobacterial potential.
QD-7	Moderate	Lower	Moderate inhibition.
QD-8	High	Comparable	Good biological performance.
QD-9	Moderate	Lower	Moderate activity.
QD-10	Low	Lower	Least active compound.

Interpretation: The antitubercular activity was maximum for the quinoline derivatives QD-4, QD-6 and QD-8 and comparatively less for QD-5 and QD-10 among the evaluated quinoline derivatives.

4.3. Comparative Anticancer Activity

The synthesized quinoline derivatives also exhibited different anticancer activity against the cancer cell models selected. Many of the derivatives had marked cytotoxic activity while others had moderate biological activity. Structural changes in the quinoline ring, such as the type and location of the substituents, seemed to have an effect on the anticancer activity. A number of compounds were found to be moderately active that are comparable to the standard reference drug.

Table 3: The comparative anticancer effect of Quinoline Derivatives

Compound	Relative Anticancer Activity	Comparison with Standard Drug	Interpretation
QD-1	Moderate	Lower	Moderate cytotoxic activity.
QD-2	Moderate	Lower	Acceptable biological response.
QD-3	High	Comparable	Strong anticancer activity.
QD-4	Very High	Comparable	Excellent cytotoxic potential.
QD-5	Moderate	Lower	Moderate biological activity.
QD-6	High	Comparable	Significant anticancer efficacy.
QD-7	Low	Lower	Limited cytotoxic activity.
QD-8	Moderate	Lower	Moderate biological response.

QD-9	High	Comparable	Promising anticancer activity.
QD-10	Low	Lower	Lowest biological activity.

Interpretation: Structural modification of the quinoline scaffold was found to be beneficial for anticancer activity, as QD-4, QD-6, and QD-9 showed better anticancer activity than the other quinoline derivatives.

4.4. Comparative Biological Performance

The anti-tubercular and anticancer activities were compared, and a few quinoline derivatives were found to have dual activity. Both biological evaluations showed these compounds to be consistently more active and to be potential multi-functional therapeutic candidates. The comparative analysis also showed that the structural modification of the quinoline framework to make suitable changes would lead to improvement in biological efficacy in different therapeutic areas.

Table 4: The comparative evaluation of the biological data is summarized

Parameter	Observation
Number of quinoline derivatives evaluated	10
Compounds showing high anti-tubercular activity	4
Compounds showing high anticancer activity	4
Compounds exhibiting dual biological activity	2
Compounds with moderate biological activity	3
Compounds with low biological activity	1
Most promising derivatives	QD-4 and QD-6
Overall outcome	Quinoline derivatives demonstrated potential as dual anti-tubercular and anticancer agents.

4.5. Structure–Activity Relationship (SAR)

The initial SAR studies indicated that the biological activity of the quinoline derivatives was related to the nature of the substituents and electronic and steric effects. In general, derivatives with electron-withdrawing functional groups showed higher biological activity than the unsubstituted derivatives or derivatives with electron-donating groups. The results of this study are beneficial and can help in designing more effective therapeutic agents based on the quinoline skeleton.

Table 5: Structure–Activity Relationship (SAR) Summary

Structural Feature	Effect on Biological Activity
Electron-withdrawing substituents	Improved anti-tubercular activity
Electron-donating substituents	Moderate anticancer activity
Halogen substitution	Enhanced overall biological activity
Multiple aromatic substitutions	Improved dual biological activity
Unsubstituted quinoline nucleus	Lower biological activity

5. Discussion

Quinoline derivatives are still very interesting to people in chemistry because these have many different effects on the body, especially against infections and cancer. In this study, the quinoline derivatives made showed levels of activity against Mtb and some cancer models. Adeniji et al., 2020 also found that the quinoline structure is still a base for making new medicines that can target both infections and cancer. This is what other people have found recently too [27].

When tested, the quinoline derivatives against TB, found that some of them were better at stopping the growth of the bacteria than others. This suggests that the activity of the molecule depends on what groups are attached to the quinoline ring and where those are attached. Liu et al., 2022 suggest chemical 5 inhibits Mtb KatG. This study found that Mtb KatG may be a novel target for anti-tubercular medication design [28].

Tested the quinoline derivatives against cancer and found that some of them were better at killing cancer cells than others. This shows that small changes to the molecule can make a difference in how well it works against cancer. Joshi et al., 2025 studied DMPK experiments, mechanistic biological investigations, structure–activity effects backed by computer docking studies, and lead optimisation and modification are discussed in this work [29].

One of the important things in this study is that some of the quinoline derivatives can work against both TB and cancer. Not many people have looked at derivatives as a way to make medicines that can work against both of these diseases. The study shows that with the design, quinoline derivatives can be effective against both TB and cancer. Heravi et al., 2023 tested chemicals that have been intentionally created, and many scientific communities have examined their biological properties. The heterocyclic quinoline ring and its derivatives' antimalarial and anticancer effects examined [30].

When looking at how the structure of the molecule affects its activity and found that the electronic and steric effects are very important. The molecules with groups that pull electrons away from the quinoline ring generally worked better than the ones with groups that donate electrons or had no groups at all. This might be because the molecules with electron-withdrawing groups can get into the cell easily and interact with the targets better. Negi et al., 2025 worked on ATP synthase being targeted by the quinazoline series, while DNA gyrase is targeted by quinoline compounds. Overall, both series have promising biological and pharmacokinetic properties. Better medicinal chemistry could boost the anti-TB potency of the identified compounds [31].

Findings also show how versatile quinoline is as a base for making medicines. Besides being used to make medicines against malaria, quinoline derivatives have been shown to work against other diseases, like infections, viruses and cancer. These can even be used to make medicines that have effects because they can incorporate many different pharmacophores without losing their activity. This makes quinoline an attractive base for making new medicines. “Rajesh 2018 also found quinolide derivatives have antimalarial, anticancer, antibacterial, anthelmintic, antiviral, antifungal, anti-inflammatory, analgesic, cardiovascular, central nervous system, hypoglycemic, and other biological effects” [32].

However, the study has some limitations. Did a test of the molecules in a laboratory setting and didn't look at exactly how these work or what their effects are in the body, and also didn't test whether these are safe or how well these are absorbed and distributed in the body. To take this further need to do studies that include computer simulations, tests in animals and other experiments to confirm that these molecules have the potential to be new medicines.
Overall, the study shows that changing the structure of the quinoline molecule can affect how well it works against TB and cancer, and found that some of the quinoline derivatives can work against both diseases, which makes them very promising for making medicines. This is in line with what other people have found: quinoline derivatives are one of the promising classes of molecules for making new medicines.

6. Conclusion

The present study comparatively assessed the biological potential of quinoline derivatives against TB and cancer, and emphasized the importance of the quinoline scaffold for further therapeutic development. The comparative biological evaluation showed that some of the synthesized derivatives showed good activity against both Mtb and selected cancer models; however, their activity depended on the changes in structure. This study suggests the importance of the correct substitution on the quinoline nucleus in improving the biological activity and can lead to improved target specificity and pharmacological activity.

The study also found that some quinoline derivatives have dual biological activities, which would make them promising candidates for the design of multifunctional pharmaceuticals. The observed structure–activity relationship parameters indicate that the electronic and steric properties of the substituent groups play significant roles in both anti-tubercular and anticancer activities, which was helpful in rationalizing the design of new quinoline-based drugs.

The overall results confirm that quinoline derivatives are potential lead molecules for further research in medicinal chemistry. The results of the present investigation are promising, but there is a need for further studies with detailed mechanistic, molecular docking, ADMET, toxicity evaluation, pharmacokinetic studies, and in vivo validation of their

therapeutic potential. The findings of this research work are part of the body of evidence that supports the importance of quinoline derivatives as a class of bioactive molecules and serve as a scientific foundation for future development of new agents for treating TB and cancer.

The future prospect of the present study indicates that quinoline derivatives are potential leads for developing novel anti-tubercular and anticancer medications. Future studies need to be focused on structural optimisation of the synthesized quinoline analogues to achieve better biological activity and selectivity. To gauge their potential therapeutic benefits, detailed structure–activity relationship (SAR) studies, molecular docking, ADMET profiling, and toxicity assessments are necessary. Moreover, in vivo pharmacological studies and clinical validation are crucial for ascertaining the safety and efficacy of the most promising derivatives. The investigations helps in developing multifunctional therapeutics for the effective control of TB and cancer that contain quinoline derivatives.

7. References

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