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**Investigating the Co-Dynamics of HIV/AIDS and Influenza in regional Australia**

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# Abstract

The abstract should be between 150-500 words. Briefly summarise your project or research. The abstract is usually written last, when you have a clear idea of your project. The aim of this section is to quickly introduce the reader to the project, and ideally engage their interest and encourage them to read the rest of the proposal. You should include an overview of the project, its motivation, the objectives, and the methods you have used, and discussions and findings. Do not include details in this section, you will have plenty of space in later sections. Also remember that the reader may not understand the technical details of your project so avoid jargon and leave in-depth discussion for later sections.

The transmission of infectious diseases is rarely independent, with another disease often shaping overall health outcomes in vulnerable populations. Regional and Indigenous populations in Australia experience disproportionately high rates of chronic and infectious diseases due to systematic inequities in healthcare access, lack of awareness and socioeconomic disadvantage. Understanding how multiple pathogens interact in such contexts is critical for designing culturally appropriate and geographically targeted interventions.

This project investigates the epidemiology of both HIV and Influenza in a regional Australian town. Computational epidemiology is used to simulate a disease spread within the Australian town of Bourke with about 2400 individuals. (Australian Bureau of Statistics [ABS], 2021). The project aims to quantify how HIV-induced immunosuppression modifies influenza transmission, prevalence and overall disease burden, with other factors such as demographic and public health responses in rural Australia.

A computational epidemiological model was developed using Python and NetworkX to generate a contact network reflective of Bourke’s demographic — namely age structure, gender distribution and Indigenous proportion (30.3%). Each node represents an individual with demographic attributes and infection states, while sexual relationships form subject to age related and monogamy constraints. HIV and influenza transmission probabilities were parameterised using data from existing epidemiological research. Influenza is modelled as a fast-spreading, short-duration infection of greater severity among immunocompromised hosts, while HIV modelled as a more slower spreading, and longer lasting infection

The method of running the simulation consisted of generating the population with nodes, each node having their own distinct parameters. The initial seeding of the two diseases. Once these two initial steps have been done,

Results show distinct patterns between both diseases. HIV prevalence rose gradually across the simulation, reflecting slow person-to-person sexual transmission. In contrast, influenza displayed a sharp epidemic curve, peaking in a short time, before declining, reflective of recovery dynamics. Influenza incidence hit the total population, highlighting that nearly all individuals were exposed.

When HIV was introduced into the population by itself, about 4.5% of the population had acquired HIV during the 730-day period. While influenza was also mixing in the population, by the end of the 730-day period, around 9.8% of the population had acquired HIV, representing about a relative increase of 10-15% in total HIV infections

The findings suggest that co-dynamics between the two diseases could significantly burden small regional towns. The model demonstrates the value of computational simulations in capturing disease interactions within realistic demographic structures. While preliminary, the results highlight the importance of tailored public health strategies in regional Australian contexts. Future work will refine the network with a more realistic approach, considering interventions such as vaccination and social distancing to reduce epidemic spread.

# Acknowledgements

If there is anyone you would like to thank or acknowledge in the completion of the project, it goes here. If there is none, you may remove this section.

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# 1. Introduction

In this section, you will describe the context of your project or research. You will introduce the general background knowledge needed to understand the research topic or problem . This may include or not restricted to the following contents:

* Research problem or description of problem that you are trying to solve
* A brief review of current knowledge or solutions, gaps in knowledge or solution and how your project fills up this gap. These are actually highlights from literature review or analysis of related works. The full findings and analysis should be in Chapter 2.
* Definition of terms (if applicable) and scope of project
* Research aim and/or research objectives
* Hypothesis (if applicable – usually for research-based projects)
* Outline of methodology
* Outline the order of the information in the thesis

## Problem statement

The transmission of infectious diseases is often influenced by the presence and prevalence of multiple diseases. In Australian regional towns, where healthcare access and demographic factors differ from metropolitan areas, the co-dynamics of HIV/AIDs and Influenza (flu) in such areas remain underexplored. As HIV/AIDs is immunocompromising, the severity of flu symptoms and transmission rates rise in a susceptible population. The extent to which HIV/AIDs affect influenza spread and outcome in regional Australia where indigenous Australians are more prevalent is still unclear.

The study aims to investigate the co-dynamics of HIV/AIDs and its impact on Influenza within the regional town of Bourke in Australia by analysing transmission dynamics, co-infection rates and healthcare implications. Bouke has a population of 2,340 (Australian Bureau of Statistics [ABS], 2021) and has a proportion of Aboriginal and Torres Strait Islander people of (30.3%). By utilizing a computational epidemiological model, the research and data that will be gathered can be used for future public health strategies not only in Bourke but other towns with a similar demographic.

# 2. Literature Review / Related Works

You might want to provide an overview of the purpose of the review before diving into your findings and its relevance to your project. Depending on the nature and context of your project, this may be a literature review (your findings from reading journal articles on similar works) or related works (your findings from comparing related projects or software which is more common for development projects). Your organization of this chapter depends on the purpose of the review and how it fits into your project aim.

## 2.1 Review Criteria 1

This sub-section presents your findings when Review Criteria 1 (Lucas et al., 2014) is applied. This is an example of in-text citation.

Table 1: Summary of comparison of X approaches to solving Y

|  |  |  |
| --- | --- | --- |
| Criteria | Work 1 | Work 2 |
| Transport Method |  |  |
| Distance Metrics |  |  |

Based on Table 1, hence, Transport Method X is chosen as the choice in my project because…

There have been many studies on the epidemiology of HIV/AIDs and Influenza separately in many different environments but not many studies on the co-dynamics between the two diseases. The co-dynamics of infectious diseases, particularly in the case of one disease altering host susceptibility to another, pose a challenge for epidemiological modelling as well as public health intervention. In immunocompromised populations, such as people living with HIV/AIDS, the introduction of a secondary pathogen like Influenza can lead to amplified transmission (Cohen et al., 2013), and more distinct epidemic patterns. This literature review will focus on transmission dynamics of both diseases, host susceptibility and modelling approaches, with a focus on regional and Indigenous Australian populations.

## 2.1 Transmission Dynamics

Transmission between the two chosen diseases differ in mechanisms, speed and susceptibility, but the interaction between the two create epidemiological patterns.

HIV/AIDs is primarily transmitted by sexual contact, specifically through the contact of body fluids from people already with HIV. Fluids such as blood, breast milk, semen and vaginal secretions. HIV also can be transmitted to a child during pregnancy and delivery. Its transmission is heavily influenced by behavioural, socio-economic and healthcare access factors. In regional and Indigenous communities of Australia, a higher HIV vulnerability has been linked to limited access to appropriate healthcare and historical marginalisation. (Ward et al. 2016). In Australia there were 633 new HIV diagnoses in 2022, with approximately 24% of such cases being Aboriginal and Torres Strait Islander people, being attributed to heterosexual contact. (Kirby Institute, 2023).

In contrast, Influenza spreads rapidly through respiratory droplets typically following a seasonal pattern. The basic reproduction number (R0) for influenza typically ranges from 1.2 to 2.0, reflecting moderate but rapid transmissibility (Biggerstaff et al., 2014). Influenza transmission is mainly influenced by population density, mobility and vaccination coverage. In Australia, over 251,000 lab confirmed influenza cases were reported in 2023 (Department of Health, 2023).

In immunocompromised individuals, such as individuals living with HIV, those also infected with influenza may exhibit longer periods of viral shedding, leading to an extended infection period and an increased risk of severe complications. A study in South Africa found that HIV-positive individuals are associated with longer viral shedding periods (median 10 days vs 5 days), and 2-8 times increase in risk of hospitalisation (Cohen et al., 2013). These altered transmission dynamics are crucial in rural towns like Bourke, where **tightly connected communities** and **healthcare access disparities** can amplify both disease spread and burden.

## 2.2 Host Susceptibility

Host susceptibility refers to the degree to which individuals or population subgroups are vulnerable to infection and disease progression. In the case of HIV/AIDS and Influenza susceptibility is shaped by immunological status, healthcare access and sociocultural determinants.

As HIV/AIDS is transmitted sexually, those that are sexually active are more likely to be susceptible to contract the disease. HIV/AIDS impairs host immune responses, specifically by depleting CD4+ T cells. This immunocompromising effect hinders the body’s ability to effectively fend of other infectious diseases such as Influenza studied here. As a result, people with HIV, have higher susceptibility in the infection of Influenza. (Cohen et al., 2013). Approximately 28% of Australians living with HIV are not virally supressed, which heightens their susceptibility to infections such as Influenza (Kirby Institute, 2023).

Influenza infection severity is generally influenced by age, comorbidities and immune status. In immunocompetent host, influenza is often self-limiting, but in populations that are immunocompromised, viral clearance is delayed, and infections are more frequent. (Kunisaki & Janoff, 2009). Notably studies have shown prolonged viral shedding among HIV-Positive individuals, which contributes to higher community transmission. In healthy adults, Influenza typically resolves within 7-10 days, but in immunocompromised individuals, including those with HIV, prolonged viral shedding is observed, with a median of 11 days (Beck et al., 2012).

In addition to the above, in Aboriginal and Torres Strait Islander individuals, there are additional layers of susceptibility. These individuals experience higher rates of chronic diseases, lower vaccination uptake and face structural barriers to healthcare access (Menzies et al., 2013). These social determinants dramatically increase vulnerabilities, increasing susceptibility to both HIV and Influenza infections and complications. This is especially in towns such as Bourke, where a high percentage of its population identifies as Indigenous (ABS, 2021).

## 2.3 Modelling Approaches

Epidemiological modelling provides a crucial framework for understanding and forecasting disease transmission and patterns, especially in complex co-infection scenarios. While both diseases have been modelled extensively in isolation, there is an absence of integrated models that captures the dynamics between the two diseases, particularly in smaller and rural populations.

HIV/AIDS models are typically based on compartmental structures such as the SIR (Susceptible-Infected-Recovered) framework extended to include chronic stages, long latency periods and behavioural risk factors. These models often incorporate stratifications by CD4 count and viral load.

Influenza models, by contrast, emphasize short term dynamics, seasonality and high transmissibility. They often use age-structured or metapopulation frameworks to simulate transmission in different types of populations, from schools, households and communities. These models are sensitive to contact patterns and mobility, factors that vary between urban and rural populations.

When modelling both diseases at once, we can consider developing a network-based model, powerful tools to simulate the transmission of diseases by representing individuals as nodes and contacts as edges, modelling the sexual contract of HIV/AIDs. One such approach is the Barabasi-Albert model which generates scale free networks. These networks are characterized by a **power law** degree distribution, meaning that most individuals will have few connections, a small number of individuals act as **superspreaders** due to a large number of contacts (Barabási & Albert, 1999). This aligns with real world dynamics where most individuals have lesser relationships formed while a few individuals will have a larger number of relationships formed, disproportionately contributing to disease spread.

In the context of HIV/AIDS, the BA model captures the fact that a small subset of the population, due to behavioural factors like high sexual activity, can maintain persistent transmission chains. Similarly, in influenza transmission, certain individuals (caregivers, community hubs) can become central to the spread due to frequent social interactions.

In regional communities such as Bourke, social networks are **tightly clustered** and highly structured, often involving overlapping family, cultural and service-related interactions. The BA model is relevant here as it allows simulation of how infections can propagate rapidly through **key individuals** or hubs.

Agent-based models are increasingly prevalent for such contexts, as they allow for fine-scale simulation of individual behaviours, local transmission clusters, and health system interactions (Ajelli & Merler, 2008). These models can be calibrated using census data available.

# 3. Methodology

This section details how you solve the problem or research question described in the Introduction. For your final thesis submission, this section should be written in past tense as you have already carried out the work. If you have not carried out the work, it should not be included in the thesis but in the Future Works section of the Conclusion.

This section will also be present in your proposal and progress report and should be written in future tense if the work have not been done.

For software development projects, you might want to outline the architecture of your system before explaining the details of implementation and approach that you took to develop the system during the project.

For research-based projects, you might want to outline the overview of your investigation process before explaining the details of how the process is carried out.

## 3.1 Data Collection

Sub-sections are useful to break your presentation into logical sequence. In each sub-section, you will then describe the details of execution and why you did what you did to get your results.

# 4. Results

This section presents what you found from your investigation or execution of the methods described in the previous section. You will need to explain the importance of our findings with respect to the problem or research question. Sometimes this section is combined with the Discussion section to immediately discuss the significance of the findings. It is recommended that you discuss with your supervisor the best approach to present your results in a coherent manner and accepted by the field.

# 5. Discussion

This section discusses the results, implications and significance of your project contributions. If your project produces unexpected results, you will need to provide plausible explanations, based on your literature review and understanding of the topic, on the phenomenon.

# 6. Conclusions

This concludes your thesis - summarize your main findings and state if you have achieved the aim and objectives that you have set out in the Introduction chapter. You might want to highlight the most significant results and your contribution before stating the limitations of your work.

If you wish to add a paragraph explaining potential future work that arises from your project, you may wish to do so here. Please discuss with your supervisor.

# Reference List

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(*2021 Bourke, Census All Persons QuickStats | Australian Bureau of Statistics*, n.d.)

# Appendix A: Ethics Approval Submission

This section is optional. If you have supplementary information that support your work but would affect the presentation of information in the main body of the thesis, you can place them in the Appendix. If you are unsure whether contents should be included in the main text of the thesis or the Appendix, please discuss with your supervisor.