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Evaluation of Interdisciplinary Integration between Common Majors and Public Health: A Mixed Methods Analysis in Health Professions Education

ABSTRACT

Interdisciplinary learning is essential for equipping future health professionals to navigate the complexities of modern public health. This mixed methods study assessed the integration of the national public health curriculum within the 17 most common first majors, analysing 801 courses at Singapore's sole school of public health, representing over 99% of students in public health programmes in the country. The study identified shared threshold concepts, competencies, and the extent of interdisciplinary interaction. Quantitative results indicated a predominantly unidirectional relationship, where most majors engaged with public health at a superficial level rather than in a reciprocal manner. Life sciences showed the highest level of unidirectional interaction, whereas pharmacy demonstrated the strongest bidirectional integration. Qualitative findings revealed thematic areas, such as research methodologies and health outcomes, but often highlighted that public health curricula merely supplemented other disciplines without enriching them. Although most majors demonstrated cross-cutting threshold concepts such as teamwork and professionalism, many significantly lacked key public health competencies pertaining to health policy and epidemiology. The study underscores considerable gaps in interdisciplinary integration and calls for substantial curricular reforms, along with institutional support and commitment, to embed essential public health competencies and promote cross-cutting threshold concepts, such as advocacy and cultural context. These changes will better prepare students to address complex public health challenges in an evolving society.

KEYWORDS

health professions education, evaluation, interdisciplinary integration, public health, higher education

INTRODUCTION

Interdisciplinary education is defined as the integration of knowledge from multiple disciplines in order to achieve outcomes that cannot be realised through a singular disciplinary approach (Holley 2017). This approach blends and links various epistemological forms, synthesising insights from multiple fields and resulting in curricula that draw upon two or more areas of study. In health professions education, interdisciplinary curricula play a crucial role in preparing future professionals to address complex and multifaceted public health challenges. By integrating

knowledge from diverse fields, interdisciplinary education equips students with the necessary skills to navigate the complexities of modern healthcare, often through inquiry-based approaches that encourage exploration and problem solving across disciplines (Hmelo-Silver 2004). As health professions increasingly require collaboration across disciplines, curricula incorporating multiple areas of study—such as public health, environmental health, and social sciences—are becoming essential (Zechariah et al. 2019). While the value of interdisciplinary education is widely acknowledged (Frenk et al. 2022), understanding its effectiveness requires clear definitions of its components and an examination of how well it is implemented, which are areas where significant literature gaps persist, potentially influenced by both curricular design and broader institutional factors.

To frame this study, it is essential to clarify the key terms used throughout: outcomes, competencies, threshold concepts, and experiences. Outcomes refer to the overarching goals or achievements that a programme aims for students to attain upon completion, such as the ability to address complex public health challenges holistically (Biggs and Tang 2011). Competencies are specific, measurable skills or abilities that students must develop to achieve these outcomes, often tied to disciplinary or interdisciplinary knowledge, such as interpreting statistical results or designing epidemiological studies (Frank et al. 2010). Threshold concepts, central to reasoning, integration, and mastery in a discipline, denote a set of ideas held by experts, such as teamwork or professionalism (Batzli et al. 2016; Clouder 2005; Rowe et al. 2020). Experiences refer to practical or contextual applications, such as collaborative projects or independent research, through which students engage with these concepts (Kolb 1984). In this study, we examined cross-cutting threshold concepts and experiences, derived from the Council on Education for Public Health (CEPH) framework, as interdisciplinary elements that may lack a specific disciplinary focus, whereas competencies often reflect a public health orientation (Council on Education for Public Health 2016). These distinctions guide our analysis of how public health curricula integrate with other disciplines, highlighting both shared foundations and discipline-specific gaps, with outcomes serving as the aim, supported by the development of competencies through the interplay of threshold concepts and experiences (Klein 2020). Despite the importance of these elements for fostering interdisciplinary education, significant gaps persist in understanding their integration within health professions curricula, which this study seeks to address.

Firstly, a key literature gap lies in the lack of empirical studies assessing the level of integration between public health curricula and other first majors in health professions education. Existing research has highlighted the need for improved interdisciplinary learning frameworks but has rarely examined how to best apply these frameworks in specific curricular contexts (Turner et al. 2022). Many health professions programmes remain siloed, placing the burden on students to independently synthesise knowledge from disparate disciplines (Zenani et al. 2023). This assumes that students are naturally able to integrate learning across fields, yet research indicates that this process requires intentional pedagogical support and curriculum design (Xu et al. 2022). Without structured guidance, students may struggle to make meaningful connections between disciplines, limiting their ability to apply interdisciplinary knowledge in real-world health contexts. Therefore, it is crucial to evaluate the extent of integration between public health curricula and other first majors in order to provide insights into how well these programmes support interdisciplinary learning.

Secondly, there is a significant gap in the literature regarding the alignment of public health principles with other health-related disciplines (Levy et al. 2022). While interdisciplinary themes are often implied in accreditation frameworks, such as those established by the CEPH, there is a scarcity

of specific studies examining the alignment between public health and other major fields (Hobson et al. 2019; Lim et al. 2020). Such alignment would ensure that essential public health competencies—such as epidemiology, health policy, and the understanding of social determinants of health—are embedded across different disciplines. Research is needed to highlight discrepancies and overlaps between public health curricula and other disciplines, as this could inform curriculum refinement to enhance interdisciplinary competency development. There is a pressing need for studies to explore how public health competencies are integrated with other majors in order to support a more cohesive and comprehensive education for health professions students.

Thirdly, existing studies have largely neglected the role of interdisciplinary education in fostering essential competencies, such as critical thinking, collaboration, and emotional intelligence, which are increasingly demanded by employers in the healthcare sector (World Economic Forum 2020). While technical skills in areas such as research methods and health policy have been extensively explored, fewer studies explore how interdisciplinary curricula contribute to the development of broader, transferable competencies. Employers in healthcare seek graduates who not only possess technical expertise but also the ability to work across disciplines, manage complex health challenges, and adapt to rapidly changing environments (Leadbeatter et al. 2023). These skills aligned with the Interprofessional Education Collaborative (IPEC) core competencies set in 2023 for collaborative practice. The development of these competencies inherently links to the interdisciplinary nature of the curriculum, yet the extent to which current public health education fosters such abilities remains under-researched (Kivits, Ricci, and Minary 2019). There is a clear need for studies that examine the role of interdisciplinary integration in enhancing these key competencies, providing valuable insights for educators and curriculum developers hoping to better prepare students to enter the healthcare workforce.

Singapore has been a role model for many countries because of its exemplary healthcare system. To continue providing high standards of care that address the increasingly complex healthcare needs of the population, it is imperative that health professions education continues to adapt and develop. In Singapore, university education typically spans three to four years, depending on the programme, and follows a modular system that integrates British and American influences, offering students the flexibility to shape their academic journeys. At the National University of Singapore (NUS), students pursue a "first major"—defined as their primary field of study, chosen at the point of admission or shortly thereafter—which forms the core of their academic training. Although pursuing a single first major is permissible, NUS offers optional second majors and minors across over 50 disciplines, spanning faculties like science, engineering, and social sciences. These offerings promote interdisciplinary learning and enable students to tailor their education to their career aspirations or personal interests. At the Saw Swee Hock School of Public Health (SSHSPH), Singapore's only national school of public health within NUS, undergraduate public health education is delivered through two programmes: a minor, introduced in 2013 to provide foundational exposure, and a second major, launched in 2021 for deeper engagement. Public health is not available as a standalone first major. Students interested in public health therefore pair it as a second major or minor with a first major in fields like biological sciences, nursing, or sociology, reflecting NUS's broad interdisciplinary framework.

This study aims to address these gaps by pursuing two specific objectives: the first aim is to evaluate the level and extent of integration between the public health curriculum and the most common first majors at NUS; the second aim is to assess the shared threshold concepts and competencies between public health and students' first majors. The data for this study, sourced from Singapore's national public health programmes, are appropriate for addressing these research

questions. The findings will offer insights relevant not only to Singapore but also to broader educational settings, ultimately enriching the discourse on integrating public health with other common majors in health professions education. Additionally, this study will shed light on interdisciplinary integration within health professions education, advocating for a more cohesive approach.

Material and methods

Study design and setting

We used a mixed methods approach, integrating both quantitative and qualitative data through a convergent parallel design. This design facilitated the analysis of qualitative and quantitative data separately, which were then compared and synthesised to yield complementary insights. The objective was to identify areas of convergence and divergence between the qualitative and quantitative findings, providing a nuanced understanding of interdisciplinary integration between common first majors and public health. The research was conducted in the university between December 2022 and June 2024. The NUS SSHSPH Departmental Ethics Review Committee approved this study (approval reference code SSHSPH-188). The research team consisted of 13 members: six core researchers (the authors of this paper) and seven other student researchers. Four core researchers (the third to sixth authors) and all seven student researchers conducted data collection. The same four core researchers performed quantitative and qualitative analyses, while the first and second authors oversaw the entire process of data collection, analysis, and interpretation.

Data collection

In addition to the minor and second major in public health programmes, we included 17 first majors at the university in the data collection, representing over 99% of the students enrolled in the public health programmes and encompassing those pursuing the second major for in-depth study and the minor for foundational public health exposure. These 17 first majors (in alphabetical order) were biomedical engineering, business administration, business analytics, chemical engineering, chemistry, computer science, data science and analytics, economics, environmental studies, food science and technology, geography, life sciences, pharmaceutical science, pharmacy, psychology, social work, and sociology. Data collection involved extensive extraction from the university educational learning platforms and the respective faculty/school websites of these 17 first majors and the public health programmes. The extracted data included curriculum and course descriptions, course outlines (including weekly lesson plan descriptions, content sequencing, learning activities, and assessments), and learning objectives, involving a total of 801 courses. The research team conducted data extraction and analysis for each first major, with peer checks performed independently by two additional team members. The team, guided by senior team members, discussed any discrepancies identified during this process until a consensus was reached. We stored the data on a secure, password-protected computer accessible only to the research team at NUS.

Framework for analysis–Aim 1

To assess the level and extent of integration between the public health curriculum and the 17 first major curricula, we used the modified Paxson's (1996) framework, which is widely applied in the literature to evaluate interdisciplinary integration within educational contexts (Gouvea et al. 2013; Grace 2021; Vess and Linkon 2023). We chose this framework for its structured approach to assessing interactions between various academic disciplines. It categorises these interactions into three distinct

levels: level 1 (L1), indicating no substantive interaction; level 2 (L2), where one discipline impacts another; and level 3 (L3), which reflects substantive connections between disciplines (Gouvea et al. 2013).

Each level captures key qualitative distinctions in how disciplines interact, affecting student learning outcomes. At L1, interactions are superficial with no meaningful exchange of ideas between the course and the public health curriculum. At L2, one discipline impacts the other: courses at this level substantially influence the public health curriculum, but the interaction is unidirectional, meaning the course remains largely unchanged while only the public health curriculum is affected. At L3, there is a bidirectional interaction: courses at this level engage deeply with the public health curriculum, with threshold concepts from both disciplines influencing and modifying each other to enhance understanding.

This tiered classification is particularly useful for systematically assessing how the public health curriculum interacts with the 17 first major curricula, providing insights into the extent to which these disciplines influence and enrich one another.

Quantitative analysis–Aim 1

The research team coded the raw data from each of the 801 courses line by line. To determine the level and extent of integration, we applied two key criteria: 1) Can the learnings from this course be applied to the public health curriculum? and 2) Is the interaction between both disciplines unidirectional or bidirectional? Each researcher conducted classifications independently and iteratively=. Two additional members then performed peer checking to ensure reliability. The researchers discussed any discrepancies identified during this process with senior team members until the team reached a consensus. The research team then categorised each first major based on the number of courses classified as L1, L2, and L3.

Courses classified as L2 and L3 underwent content analysis to identify the presence and frequency of keywords in the raw data. Using the course learning objectives, course outlines, course descriptions, and curricula, the research team generated the codes. We then recorded the frequency of each code. Within each first major, we grouped codes with similar meanings and calculated their frequency and proportions. Similarly, across all first majors, we consolidated codes with comparable meanings into a final set of word combinations that effectively represented the original codes. The team then calculated the frequency and proportion of these word combinations as a percentage of the total number of codes across all 17 first majors (N = 2,620). We conducted all statistical analyses using STATA version 15.0 (Stata Corp, College Station, TX, USA).

Qualitative analysis–Aim 1

To answer the first research aim of exploring the interdisciplinary interactions between the public health curriculum and the common first majors, we employed a qualitative document analysis of the course descriptions, course outlines, and learning objectives from the latest academic year available on the NUS website and internal curriculum archives. Two members of the research team (the fourth and fifth authors) independently coded the documents using an inductive, inquiry-based approach; they systematically investigated how course content facilitated connections across disciplines (Savin-Baden and Major 2013) using NVivo 11.0. This process identified emergent themes of interdisciplinary interactions, such as “unidirectional interactions” (where knowledge from one discipline informs another) and “bidirectional interactions” (where disciplines mutually inform one another). Following this, the team grouped codes into broader themes through consensus discussions

with senior team members, ensuring robust interpretation of the data and highlighting how inquiry underpinned the exploration of interdisciplinary integration.

Framework for analysis–Aim 2

We used the competency framework from the CEPH for the second research aim of evaluating the shared competencies between the public health curriculum and the common first majors, owing to its comprehensive and widely recognised standards in public health education (Hobson et al. 2019). CEPH is an accrediting body that establishes and promotes educational quality in public health programmes, providing a framework that delineates both competencies—specific skills and abilities required for effective public health practice, such as interpreting statistical data or understanding health policy—and cross-cutting threshold concepts and experiences, which are broader, interdisciplinary foundations (e.g., teamwork, independent work) and their practical applications (Hobson et al. 2019). These collectively contribute to educational outcomes, such as preparing students for collaborative and impactful public health careers. The SSHSPH developed and mapped the curriculum of the national public health programmes at the university using the CEPH framework and guidelines (Lim et al. 2020), ensuring alignment with contemporary public health challenges. This framework's structure allows us to systematically compare how competencies, often public health-specific, and cross-cutting threshold concepts and experiences, which may appeal across disciplines, are integrated with the first majors, illuminating the depth of interdisciplinary learning.

Quantitative analysis–Aim 2

Our analysis involved categorising the total number of courses within each first major that met the specific requirements outlined by CEPH, contributing to broader educational outcomes such as readiness for public health practice. We evaluated two key domains: cross-cutting threshold concepts and experiences (broad, interdisciplinary ideas such as professionalism and their practical applications, like teamwork exercises) and public health competencies (specific, measurable skills tied to public health practice such as designing epidemiological studies). The CEPH framework outlines 12 essential cross-cutting threshold concepts and experiences that public health students should engage with throughout their academic journey, alongside 12 key public health competencies that they must develop to become effective professionals. These collectively support the programme's outcomes of producing well-rounded graduates equipped for diverse public health demands. The research team assessed each course for evidence of alignment with these cross-cutting threshold concepts and experiences or public health competencies. The research team conducted this evaluation for each first major, with independent peer checks performed by two additional team members. Discussions with senior team members resolved any discrepancies identified. Following this, we calculated the proportion of courses in each first major that met each competency. This analysis provided valuable insights into how closely the curricula of each first major aligned with public health education standards.

RESULTS

Quantitative findings–Aim 1

Table 1a shows Paxson's levels of interaction between the public health curriculum and the 17 first major curricula. A high proportion of courses across all first majors exhibited no substantive interaction with the public health curriculum (L1), with computer science standing out as the only major where all its courses had no interaction. Among the majors with interactions, life sciences

exhibited the highest level of unidirectional interaction (L2), with 53.0% of its courses influencing or modifying the public health curriculum without being reciprocally affected. Pharmacy demonstrated the strongest bidirectional interaction (L3), with 33.3% of its courses showing a significant mutual connection with the public health curriculum.

Table 1a. Paxson's levels of interaction between the public health curriculum and the 17 first major curricula

First major *(in alphabetical order)*	**Frequency of courses** *(as a % of the total number of courses offered in the first major)*			**Total number of courses within first major**
	L1	**L2**	**L3**	
Biomedical engineering	20 (83.3)	3 (12.5)	1 (4.2)	24
Business administration	9 (69.2)	4 (30.8)	0 (0.0)	13
Business analytics	36 (69.2)	15 (28.9)	1 (1.9)	52
Chemical engineering	23 (88.5)	2 (7.7)	1 (3.8)	26
Chemistry	60 (90.9)	6 (9.1)	0 (0.0)	66
Computer science	12 (100)	0 (0.0)	0 (0.0)	12
Data science and analytics	31 (83.8)	6 (16.2)	0 (0.0)	37
Economics	40 (69.0)	12 (20.7)	6 (10.3)	58
Environmental studies	20 (83.4)	2 (8.3)	2 (8.3)	24
Food science and technology	26 (68.4)	8 (21.1)	4 (10.5)	38
Geography	63 (86.3)	9 (12.3)	1 (1.4)	73
Life sciences	39 (38.2)	54 (53.0)	9 (8.8)	102
Pharmaceutical science	20 (91.0)	1 (4.5)	1 (4.5)	22
Pharmacy	10 (41.7)	6 (25.0)	8 (33.3)	24
Psychology	61 (53.0)	41 (35.7)	13 (11.3)	115
Social work	17 (63.0)	6 (22.2)	4 (14.8)	27
Sociology	55 (62.5)	22 (25.0)	11 (12.5)	88

Table 1b presents the most common word combinations by frequency and proportion, along with the corresponding first major(s). The term "quantitative research methods" appeared most frequently, with 263 occurrences (10.04%) in psychology, followed by "social determinants of health," which had 223 occurrences (8.51%) in sociology. Other word combinations covered a range of topics, with proportions ranging from just over 1% to nearly 3.6%, such as "urbanisation" (94 occurrences, 3.59%), "mental health conditions" (68 occurrences, 2.60%), "drug discovery and development" (43 occurrences, 1.64%), and "data visualisation" (29 occurrences, 1.11%).

Table 1b. Most common word combinations across the 17 first majors

Word combinations	**Frequency**	**Proportion (%)**	**First major**
Quantitative research methods	263	10.04%	Psychology
Social determinants of health	223	8.51%	Sociology
Urbanisation	94	3.59%	Biomedical engineering, chemical engineering, geography
Human physiology and disease	84	3.21%	Life sciences, pharmacy

Microbiology	82	3.13%	Environmental studies, food science and technology, life sciences, pharmaceutical science, pharmacy
Non-social factors influencing human health	81	3.09%	Pharmacy, psychology
Mental health conditions	68	2.60%	Psychology, social work, sociology
Vulnerable groups	61	2.33%	Geography, sociology
Qualitative research methods	60	2.29%	Sociology
Statistics and probability	57	2.18%	Biomedical engineering, business administration, business analytics, chemical engineering, chemistry, data science and analytics, economics, pharmacy, social work
Health policy	54	2.06%	Economics, life sciences, pharmacy, social work, sociology
Communicating data	53	2.02%	Psychology, sociology
Drug discovery and development	43	1.64%	Chemistry, life sciences
Pharmacology	41	1.56%	Life sciences, pharmacy, psychology
Healthcare system	36	1.37%	Business analytics, pharmaceutical science, pharmacy, psychology, sociology
Ageing	35	1.34%	Economics, life sciences, psychology, social work, sociology
Immunology	35	1.34%	Life sciences

Data modelling	30	1.15%	Biomedical engineering, business administration, business analytics, chemical engineering, data science and analytics, geography
Data analysis	30	1.15%	Business administration, business analytics, chemistry, data science and analytics, geography, psychology
Nutrition	30	1.15%	Food science and technology, life sciences
Genetics and gene therapy	30	1.15%	Life sciences
Data visualisation	29	1.11%	Business analytics, data science and analytics, psychology

Qualitative findings–Aim 1

Table 2 outlines the themes and subthemes related to the extent of integration between the public health curriculum and the curricula of the 17 first majors. Six key themes emerged: 1) research methodology, 2) factors influencing human health and disease, 3) approaches to improving health outcomes, 4) health delivery, 5) sustainability, and 6) applications and dissemination of data. Appendix C presents the illustrative quotes for the themes and subthemes in Table 2.

Table 2. Themes and subthemes on the extent of integration between the public health curriculum and the 17 first major curricula

Theme	Subthemes
Research methodology	- Qualitative research methods - Quantitative research methods
Factors influencing human health and disease	- Mental factors - Physical factors - Social factors
Approaches to improving health outcomes	- Preventive approaches to improving health - Biomedical approaches to improving health
Health delivery	- Health policies - Health systems
Sustainability	- Natural environment - Man-made environment
Applications and dissemination of data	- Data analysis - Data visualisation - Data modelling - Data communication

A shared focus across curricula is the synthesis of new information through both qualitative and quantitative research methods, fostering an interdisciplinary approach when coupled with course assignments that emphasise public health. For qualitative methods, sociology students are introduced to key techniques such as interviews, focus groups, and discourse analysis (SC3221, Qualitative Inquiry), which align with public health courses such as SPH2001 (Fundamental Public Health Methods), where similar research processes are taught. Additionally, the assessments in these courses encouraged a focus on public health applications. In terms of quantitative methods, psychology students develop competencies in inferential statistics (PL2131, Research and Statistical Methods I) and R programming for data exploration (PL2132, Research and Statistical Methods II), competencies relevant to higher-level public health courses like SPH3106 (Data Analysis for Pathogen Genomics) and SPH3107 (Infectious Disease Modelling for Public Health). However, the integration is largely unidirectional, as some specialised competencies, such as those related to pathogen genomics, do not directly apply to social science contexts.

Public health also overlaps with first majors in areas concerning factors affecting human health and disease. These are classified into mental, physical, and social factors. For mental factors, psychology covers topics such as anxiety, depression, and psychosis (PL3106, Mental Health and Distress); physical factors include epigenetic processes related to disease (LSM3235, Biomedical Applications of Human Epigenetics); and social factors encompass areas including social determinants of health and medical systems (SC2211, Medical Sociology). Public health courses such as SPH3402 (Mental Health: An Interdisciplinary Approach), SPH2402 (Public Health and Innovations for Ageing Populations), and SPH2005 (Health, Society, and the Social Determinants) provide threshold concepts that can deepen students' understanding of these factors. The integration is often more bidirectional at the conceptual level, with each curriculum potentially enhancing the other by sharing foundational ideas (e.g., mental health frameworks informing public health, social determinants enriching sociology). However, this enhancement could be further realised through purposeful interdisciplinary experiences—such as joint case studies between psychology and SPH3402 (Mental Health: An Interdisciplinary Approach) or interdisciplinary seminars linking SC2211 (Medical Sociology) and SPH2005 (Health, Society, and the Social Determinants). This, however, is dependent on educator collaboration, which our data suggest is not yet widespread.

In terms of approaches to improving health outcomes, first majors such as food science and technology focus on preventive strategies like dietary antioxidants and their role in mitigating chronic disease (e.g. FST5301A, Scientific Principles of Nutraceuticals), while pharmacy courses emphasise health screenings and preventive medicine (e.g. PR2154, Respiratory System: Science & Therapeutics). Biomedical approaches are covered in Pharmaceutical Science (e.g. PHS2102, Physicochemical and Biochemical Principles of Drug Action) and Pharmacy (e.g. PR1153, Pharmacy Foundations: Science & Therapeutics II), which focus on drug development and infection control. These preventive and biomedical threshold concepts complement public health courses such as SPH2202 (Public Health Nutrition) and SPH2401 (Introduction to Global Health). However, the integration is again predominantly unidirectional, with public health courses offering supplementary threshold concepts rather than deeply influencing the majors.

Health delivery is another area of intersection, covering aspects from health systems and policies to patient flow and care planning. Pharmacy and social work students engage with health policies (SW3220, Introduction to Social Policy) and systems models (PR2154, Respiratory System: Science & Therapeutics), which align with public health courses such as SPH3401 (Designing Public Health Programmes). However, this interaction remains minimal and unidirectional.

Sustainability covers both natural and man-made environments, and is integrated. First majors such as chemistry examine threshold concepts such as climate change and pollution (e.g. CM3261, Environmental Chemistry), while chemical engineering explores urban sustainability (e.g. EG2501, Liveable Cities) These themes relate to public health courses such as SPH2203 (Food Environments, Nutrition, & Health: Understanding Key Drivers, Actors, and Solutions) and SPH3204 (One Health: People, Animals, and the Environment), although the integration remains unidirectional, with public health providing supplementary threshold concepts without contributing to a deeper understanding of specialised fields, such as climate change governance.

Finally, the application and communication of data are integral across disciplines. First majors such as data science and analytics focus on detailed aspects of data manipulation (e.g. DSA2101, Essential Data Analytics Tools: Data Visualisation), while business administration emphasises statistical modelling (e.g. DAO1704, Decision Analytics using Spreadsheets). Psychology students also develop competencies in scientific communication (e.g. PL3281, Lab in Cognitive Psychology). These competencies align with public health courses such as SPH3101 (Biostatistics for Public Health), but the integration is primarily unidirectional, as each discipline's data applications remain context specific.

Quantitative findings–Aim 2

Appendix A shows the frequency and proportion of courses presenting with cross-cutting threshold concepts and experiences, per the CEPH framework. The cross-cutting threshold concept of "independent work and a personal work ethic" was the most widely integrated, with 100% of economics courses incorporating this threshold concept through experiences such as assessments. In contrast, only 29.2% of environmental studies courses included it. Two other significant cross-cutting threshold concepts, "teamwork and leadership" and "professionalism," were present across all first majors via various experiences; however, "professionalism" was notably less represented in sociology (1.1% of courses) and life sciences (1.0% *of* courses), reflecting variability in how curricula apply these threshold concepts, often depending on course design and context (e.g., public health focus). The findings regarding cross-cutting threshold concepts specifically related to public health, such as "advocacy for the protection and promotion of public health at all societal levels" (present in courses across seven first majors) and "cultural contexts in which public health professionals operate" (present in four first majors), suggest limited integration. This reflects both the curricular design and the degree to which educators emphasise these threshold concepts through experiences like assessments or teamwork activities, highlighting the potential for greater interprofessional application depending on instructional strategies.

Appendix B illustrates the frequency and proportion of courses presenting with public health competencies, per the CEPH framework. The competency "interpret basic statistical results" appeared in 13 out of 17 first majors, aligning with earlier analyses that identified "quantitative research methods" as a leading word combination. "Research methodology" and "applications and dissemination of data" were also major themes. However, certain competencies specifically relevant to public health, such as "understand the processes of health policy formulation and implementation" (present in social work– 11.1%, economics– 8.6%, sociology– 1.1%) and "design and conduct a basic epidemiological study" (present in data science and analytics– 5.4%, sociology– 1.1%), were less frequently represented. These findings indicate potential gaps in competency development vital to public health practice and suggest that the disciplinary focus of these competencies may limit their broader interdisciplinary uptake.

DISCUSSION

This mixed methods study examined the integration of public health curricula with common first majors, revealing significant gaps in meaningful interaction across many disciplines, consistent with the observation that "despite the rhetoric surrounding interdisciplinary education, many programmes continue to operate in silos" (Beltran and Miller 2020). While majors such as life sciences and pharmacy demonstrated more frequent unidirectional or bidirectional interactions because of their shared foundational knowledge, only one-third to a half of the courses reflected higher levels of integration. The predominant areas of interaction focused on "quantitative research methods" and "social determinants of health," particularly in psychology and sociology, encompassing research methodologies, factors influencing human health and disease, and strategies for improving health outcomes. The study also identified prevalent cross-cutting threshold concepts and experiences; "independent work and a personal work ethic" was the most common across all first majors, but was especially prevalent in economics, reflecting a broad, interdisciplinary foundation. However, public health threshold concepts, such as "advocacy for the protection and promotion of public health" and "cultural contexts in which public health professionals operate," were underrepresented, with only seven majors addressing advocacy and four incorporating cultural contexts. While many curricula represented the competency "interpreting basic statistical results," they lacked crucial public health competencies like "understand health policy formulation" and "conduct basic epidemiological studies," suggesting that curricular integration alone may not fully explain the interdisciplinary shortfall, and institutional factors could also play a role.

This study's focus on public health integration raises questions about students' broader academic pathways at the university, where they can pair any of the 17 first majors with a second major other than public health, such as business or engineering, in addition to or instead of public health. They can also opt for a public health minor for a lighter interdisciplinary touch. This flexibility introduces potential challenges in balancing interdisciplinary integration across multiple fields. For instance, a student with a first major in life sciences and a second major in business administration may face competing demands to integrate biological knowledge with business principles, potentially diluting the depth of public health exposure if it is pursued only as a minor or not at all. This complexity suggests that achieving robust interdisciplinary connections with public health may be more feasible for majors with inherent overlaps, such as pharmacy or life sciences, where shared content (e.g., human physiology, pharmacology) naturally aligns with public health competencies. Conversely, majors with less direct relevance to health outcomes, like computer science or chemical engineering, may not warrant extensive interdisciplinary linkage with public health, as their core focus (e.g., algorithms, chemical processes) diverges significantly from public health priorities. Thus, while interdisciplinary integration is valuable, its appropriateness and depth may vary by major, depending on disciplinary alignment and student academic choices.

Within NUS and SSHSPH, the presence of multiple programmes and majors introduces competing priorities that can complicate alignment with the public health curriculum. Emphasising public health in one major to create synergy—such as integrating health policy into economics—may inadvertently reduce synergy with other major combinations where analytical priorities dominate, such as economics paired with data science. This creates a ripple effect, as efforts to align one discipline with public health may disrupt existing interdisciplinary connections across other departments, necessitating broader collaboration. For example, fostering public health integration in computer science (e.g., through health informatics) could strain resources or focus within

programmes already aligned with engineering or business, highlighting the need for coordinated, institution-wide strategies that balance competing demands (Klein 2021).

Beyond identifying curricular gaps, this study draws attention to the role of inquiry in fostering interdisciplinary integration. Our qualitative analysis relied on an inquiry-based approach to uncover how public health competencies and cross-cutting threshold concepts interact with first majors, revealing patterns like bidirectional interactions in life sciences and pharmacy. This suggests that inquiry, as a pedagogical tool, may deepen interdisciplinary learning by encouraging students to explore connections across fields, ask critical questions, and synthesise diverse perspectives (Hmelo-Silver 2004). For example, courses emphasising inquiry—such as those requiring students to investigate social determinants of health or design epidemiological studies—could bridge gaps in underrepresented competencies like "understand health policy formulation." Future curricula could leverage inquiry-based learning to enhance integration, particularly for majors with less inherent overlap with public health, through challenging students to actively seek interdisciplinary solutions to complex health problems, thereby aligning with the broader goals of health professions education.

This study's findings reveal considerable variability in the integration levels between the public health curriculum and the 17 first majors, with many showing limited interaction with public health content. This aligns with previous studies, such as Beltran and Miller (2020), suggesting that despite the rhetoric surrounding interdisciplinary education, many programmes continue to operate in silos. For instance, majors such as computer science demonstrated minimal interaction with the public health curriculum, while life sciences and pharmacy exhibited more frequent, albeit limited, interactions. Even within these latter disciplines, only one-third to a half of the courses displayed higher-level interactions, underscoring the challenges of achieving deeper integration. When integration occurred, it primarily focused on specific topics, such as research methods and social determinants of health, where overlaps between disciplines were most evident. Despite existing literature emphasising the importance of interdisciplinary knowledge (Xu et al. 2022), the narrow scope of integration suggests that the interdisciplinary approach remains underdeveloped. These findings align with previous research on the challenges of interdisciplinary integration in health professions education. Earlier studies have critiqued the siloed nature of curricula within health-related fields, where students are expected to independently synthesise knowledge across disciplines without adequate structured support (Oudenampsen et al. 2023; Turner et al. 2022). By empirically evaluating the level of integration between public health and other majors, this study addresses a crucial gap, revealing that while some degree of integration is present, it tends to be unidirectional. This reinforces the urgent need for deliberate curricular design, as well as institutional support and commitment in order to foster interdisciplinary learning, as emphasised by Xu et al. (2022).

To address this, high impact practices, such as learning communities, could offer a promising framework. Learning communities encourage integration of learning across courses since they link two or more classes, enabling students to explore "big questions" through diverse disciplinary lenses and often connecting liberal arts and professional fields or incorporating service learning (Association of American Colleges and Universities n.d.). Such practices, which form part of the foundation for the National Survey of Student Engagement (NSSE) findings on undergraduate education quality (n.d.), could enhance interdisciplinary connections in this context.

Another notable finding is the prominence of cross-cutting threshold concepts, particularly "independent work and a personal work ethic," which all majors prioritised, especially economics, reflecting Jacob's (2015) emphasis on professional education. However, essential public health threshold concepts, such as "advocacy for public health" and "cultural contexts," were significantly underrepresented, which suggests a limited exposure to the societal and cultural dimensions of

health that are imperative for addressing health disparities. This presents an opportunity for public health educators to be more deliberate in helping students make connections between these threshold concepts, their primary disciplines, and public health, for example, through incorporating experiential learning activities with post-activity reflection, or by providing interdisciplinary projects for senior students who have sufficient discipline-specific understanding and are able to independently draw links between the two fields in order to further develop these threshold concepts (Golding 2009).

The study also revealed significant gaps in the integration of other public health competencies. While foundational skills such as "interpreting basic statistical results" were commonly included, more specialised competencies, such as those related to health policy and epidemiology, were notably absent. These higher-order public health skills are essential for comprehending health systems and implementing population-level interventions (Oh, Abazeed, and Chambers 2021; Rod et al. 2023). This indicates that while students may acquire analytical abilities, they are often deprived of essential public health knowledge required to effectively translate data into practice (Gonzales et al. 2012). Consequently, this highlights the necessity for public health education to broaden its scope beyond its traditional curriculum.

Achieving meaningful interdisciplinary integration also requires a plan to address systemic barriers within post-secondary institutions, such as chronic underfunding and outdated structures, which perpetuate siloed teaching and learning. Emerging trends, including increased demand for sustainability, equity, and technological integration, necessitate structural, funding, and operational overhauls in order to better support interdisciplinary collaboration (Colleges and Institutes Canada 2024). For instance, reallocating resources to support co-teaching models or interdisciplinary research initiatives could enable educators to move beyond disciplinary silos, fostering integrated curricula that align public health with other fields. These systemic changes, beyond curricular reform, are crucial to creating an environment where educators and students can collaboratively address complex health challenges. This study highlights the need for such overhauls; future research could explore how institutional restructuring enhances interdisciplinary education, potentially informing policy and practice in higher education.

Recommendations for educational practice and future directions

This study's findings underscore several important implications for curriculum development. Universities should take proactive measures to enhance interdisciplinary integration between public health and other majors, particularly in underrepresented fields such as computer science, economics, and engineering. Curriculum developers must incorporate key public health competencies in order to ensure that all students, regardless of their major, gain essential public health knowledge (MacKay et al. 2023). For example, computer science programmes could include health informatics, while economics might integrate health policy and social determinants of health. To foster interdisciplinary integration in health professions education, curriculum designers should prioritise bidirectional interactions between public health and other disciplines. While pharmacy demonstrated some bidirectional integration, areas such as computer science showed no interaction at all. Encouraging mutual influence between disciplines would significantly enhance students' ability to apply interdisciplinary knowledge in real-world contexts.

Moreover, there is a pressing need for the explicit inclusion of public health threshold concepts related to advocacy and cultural context. By integrating these threshold concepts, universities can prepare students to more effectively contribute to public health promotion and

disease prevention (Handtke, Schilgen, and Mösko 2019). Additionally, prioritising certain foundational public health competencies, such as those related to health advocacy and cultural sensitivity, across relevant first majors is crucial. This strategy would ensure that students from diverse backgrounds, whether in the social sciences or natural sciences, study fundamental public health principles, thereby fostering a more cohesive understanding of health challenges.

The findings also stress a critical need for curricular reforms that break down the silos separating public health from other disciplines. Achieving this requires bidirectional integration, allowing public health to influence, and be influenced by, other fields. Curriculum developers should align public health competencies with those of other majors to cultivate a shared understanding of health challenges. By developing new interdisciplinary courses or enhancing existing ones so that they incorporate these competencies, universities can ensure that all students, regardless of their major, graduate with a comprehensive understanding of essential public health threshold concepts that are crucial for navigating today's interconnected health landscape (Kiviniemi and Przybyla 2019; MacKay et al. 2023).

Future research might address how integrated curricula influence student preparedness for careers that demand interdisciplinary knowledge. Longitudinal studies could offer valuable insights into how curricula evolve in response to emerging public health challenges and could assess their effectiveness in addressing real-world issues. Furthermore, it is essential to explore the development of intentional pedagogical frameworks that promote deeper interdisciplinary engagement, supported by institutional commitment. These frameworks could encompass co-teaching models, where educators from various disciplines collaborate on course design and delivery, inquiry-based learning that encourages students to investigate and connect threshold concepts across fields (Savin-Baden and Major 2013), and problem-based interdisciplinary approaches that challenge students to apply knowledge from multiple fields in order to tackle complex health problems. These all require time, resources, and institutional support to enable educator collaboration and overcome siloed structures.

Strengths and limitations

One of the strengths of this study is its mixed methods design, which facilitates a comprehensive exploration of interdisciplinary integration through both quantitative and qualitative data. This approach provides a nuanced understanding of how public health interacts with various majors, contributing valuable insights to the existing literature. Additionally, the study examines a diverse array of disciplines, highlighting the variable nature of interdisciplinary integration. This broad scope increases the applicability of the findings across different fields and offers essential insights for curriculum developers involved in a wide range of educational programmes. Moreover, the study's focus on cross-cutting threshold concepts and public health competencies represents a novel contribution to the study of interdisciplinary learning. By mapping these competencies, the research identifies areas of strength and opportunity that can guide future curriculum reforms. The research team's composition, which includes both student and faculty representatives, further enhances the validity of these findings by incorporating key stakeholder perspectives.

However, this study has some limitations. First, while it centres on a single institution, it is worth noting that this institution is the only national school of public health in Singapore, and the programme serves as a national undergraduate initiative. This context amplifies the significance of the findings, reflecting a comprehensive representation of public health education across the nation. To further mitigate the limitation of generalisability, future research could include comparative studies with other public health programmes to assess whether similar trends and integration practices exist elsewhere.

Second, the study identifies gaps in curricular integration but does not fully explore the underlying mechanisms driving these gaps, particularly the role of educators and students in translating curriculum into interdisciplinary practice. By focusing primarily on curricular content, we capture potential opportunities for integration but lack data about actual learning experiences that determine whether interdisciplinary integration or interprofessionalism is occurring. While Paxson's (1996) framework helps classify curricular interactions, it may not suffice to assess integration at the delivery level. Therefore, we propose co-teaching models and problem-based learning as solutions, but we did not investigate why such strategies are absent, nor did we examine institutional factors like time, resources, or support for these approaches, which are paramount to fostering interdisciplinary teaching. Future research should incorporate educator and student perspectives alongside institutional analyses to bridge this gap.

Third, the predominantly unidirectional integration observed in many majors may not fully capture the complexity of interdisciplinary learning. Although the study highlights instances where public health content is integrated into other disciplines, it does not explore how other fields might influence the public health curriculum. This lack of bidirectional integration may limit the study's ability to evaluate the full potential of interdisciplinary education. To address this gap, future studies might incorporate broader feedback mechanisms, such as interdisciplinary faculty workshops, to facilitate mutual influence and integration across disciplines.

Lastly, the study does not account for the longitudinal impact of interdisciplinary integration on student learning outcomes. While it captures the current state of curriculum integration, it does not track how exposure to public health threshold concepts influences students' skills, competencies, or career trajectories over time. Future research could employ longitudinal study designs in order to evaluate the long-term effects of integrated curricula on student preparedness for addressing public health challenges in their professional careers. This approach would yield deeper insights into how interdisciplinary learning shapes real-world competencies and enhances readiness for the healthcare workforce.

CONCLUSION

This study provides pivotal insights into the current state of interdisciplinary learning within a national undergraduate public health programme in Singapore. It reveals substantial gaps in integration, particularly regarding key public health competencies related to health policy and epidemiology. To address these gaps, programmes may need to implement significant curricular reforms, ideally with institutional support and commitment—such as embedding key public health competencies across various disciplines and promoting cross-cutting threshold concepts like advocacy and cultural context. By implementing these changes, universities can better prepare students to tackle complex public health challenges in a rapidly evolving health landscape.

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DISCLOSURE

We used generative AI software (Canva AI) to create the image incorporated in *Teaching & Learning Inquiry*.

ETHICS

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The National University of Singapore's Saw Swee Hock School of Public Health Departmental Ethics Review Committee approved this study (approval reference code SSHSPH-188). We obtained informed consent from all participants.

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APPENDIX A

Frequency and proportion of courses presenting with cross-cutting threshold concepts and experiences per the council on education for public health framework

Frequency of courses with cross-cutting threshold concepts and experiences (*as a % of the total number of courses offered in the first major*)												
First major *(n = total number of courses within first major)*	Advocacy for protection and promotion of the public's health at all levels of society	Community dynamics	Critical thinking and creativity	Cultural contexts in which public health professionals work	Ethical decision making as related to self and society	Independent work and a personal work ethic	Networking	Organisational dynamics	Professionalism	Research methods	Systems thinking	Teamwork and leadership
Biomedical engineering (n = 24)	-	4 (16.7)	10 (41.7)	-	2 (8.3)	23 (95.8)	-	1 (4.2)	10 (41.7)	-	4 (16.7)	11 (45.8)
Business administration (n = 13)	-	-	7 (53.8)	-	-	7 (53.8)	1 (7.7)	1 (7.7)	10 (76.9)	-	5 (38.5)	10 (76.9)
Business analytics (n = 52)	-	-	1 (1.9)	-	-	33 (63.5)	-	-	29 (55.8)	-	-	28 (53.8)
Chemical engineering (n = 26)	-	4 (15.4)	8 (30.8)	-	1 (3.9)	23 (88.5)	-	-	12 (46.2)	-	2 (7.7)	12 (46.2)
Chemistry (n = 66)	-	-	3 (4.5)	-	-	50 (75.8)	4 (6.1)	2 (3.0)	14 (21.2)	2 (3.0)	-	17 (25.8)
Computer science (n = 12)	-	-	-	-	1 (8.3)	10 (83.3)	-	-	2 (16.7)	-	-	2 (16.7)
Data science and analytics (n = 37)	-	-	4 (10.8)	-	-	14 (37.8)	-	-	5 (13.5)	6 (16.2)	-	3 (8.1)
Economics (n = 58)	-	2 (3.4)	7 (12.1)	-	2 (3.4)	58 (100)	39 (67.2)	-	29 (50.0)	10 (17.2)	2 (3.4)	25 (43.1)

Environmental studies (n = 24)	-	-	-	-	1 (4.2)	7 (29.2)	-	-	2 (8.3)	1 (4.2)	-	9 (37.5)
Food science and technology (n = 38)	1 (2.6)	-	3 (7.9)	-	-	17 (44.7)	1 (2.6)	-	7 (18.4)	-	-	7 (18.4)
Geography (n = 73)	1 (1.4)	2 (2.7)	16 (21.9)	1 (1.4)	2 (2.7)	63 (86.3)	5 (6.8)	5 (6.8)	53 (72.6)	13 (17.8)	6 (8.2)	53 (72.6)
Life sciences (n = 102)	1 (1.0)	-	12 (11.8)	-	7 (6.9)	68 (66.7)	2 (1.9)	1 (1.0)	1 (1.0)	5 (4.9)	-	28 (27.5)
Pharmaceutical science (n = 22)	-	-	8 (36.4)	-	-	8 (36.4)	1 (4.5)	-	9 (40.9)	7 (31.8)	-	5 (22.7)
Pharmacy (n = 24)	9 (37.5)	2 (8.3)	12 (50.0)	2 (8.3)	7 (29.2)	15 (62.5)	5 (20.8)	3 (12.5)	17 (70.8)	10 (41.7)	3 (12.5)	20 (83.3)
Psychology (n = 115)	15 (13.0)	14 (12.2)	25 (21.7)	1 (0.9)	8 (7.0)	69 (60.0)	-	-	12 (10.4)	43 (37.4)	5 (4.3)	44 (38.3)
Social work (n = 27)	2 (7.4)	4 (14.8)	8 (29.6)	1 (3.7)	2 (7.4)	17 (63.0)	3 (11.1)	3 (11.1)	17 (63.0)	2 (7.4)	2 (7.4)	15 (55.6)
Sociology (n = 88)	20 (22.7)	12 (13.6)	22 (25.0)	-	3 (3.4)	64 (72.7)	1 (1.1)	3 (3.4)	1 (1.1)	15 (17.0)	6 (6.8)	25 (28.4)

APPENDIX B

Frequency and proportion of courses presenting with public health competencies per the Council on Education for Public Health framework

Frequency of courses with public health competencies (*as a % of the total number of courses offered in the first major*)												
First major *(n = total number of courses within first major)*	A. Understand the role of public health in society	B. Understand the role and function of health delivery systems	C. Understand the processes of health policy formulation and implementation	D. Use data from various sources to characterise the health of a population or subpopulation	E. Identify political, cultural, behavioural, and socioeconomic factors related to common Public Health issues	F. Apply basic preventive approaches to disease prevention and health promotion for the individuals and community	G. Design and conduct a basic epidemio-logical study	H. Interpret basic statistical results	I. Interpret basic qualitative results	J. Locate, use, and evaluate public health information	K. Communicate public health information in both verbal and written forms	L. Work effectively as a member of a public health team
Biomedical engineering (n = 24)	-	-	-	1 (4.2)	1 (4.2)	-	-	3 (12.5)	1 (4.2)	-	-	-
Business administration (n = 13)	-	-	-	-	-	-	-	3 (23.1)	-	-	-	-
Business analytics (n = 52)	-	-	-	-	-	-	-	21 (40.4)	-	1 (1.9)	-	-
Chemical engineering (n = 26)	-	-	-	-	1 (3.8)	-	-	2 (7.7)	1 (3.8)	-	-	-
Chemistry (n = 66)	-	-	-	-	-	1 (1.5)	-	5 (7.6)	-	-	-	-
Computer science (n = 12)	-	-	-	-	-	-	-	-	-	-	-	-

Data science and analytics (n = 37)	-	-	-	-	-	-	2 (5.4)	18 (48.6)	-	-	-	-
Economics (n = 58)	1 (1.7)	-	5 (8.6)	1 (1.7)	2 (3.5)	-	-	6 (10.3)	-	2 (3.5)	1 (1.7)	2 (3.5)
Environmental studies (n = 24)	-	-	-	-	-	-	-	-	-	-	-	-
Food science and technology (n = 38)	-	-	-	-	1 (2.6)	-	-	-	-	-	-	-
Geography (n = 73)	-	-	-	1 (1.4)	2 (2.7)	-	-	12 (16.4)	11 (15.1)	-	2 (2.7)	1 (1.4)
Life sciences (n = 102)	2 (1.9)	1 (1.0)	-	1 (1.0)	2 (1.9)	2 (1.9)	-	-	-	1 (1.0)	1 (1.0)	1 (1.0)
Pharmaceutical science (n = 22)	-	-	-	-	-	-	-	1 (4.5)	-	-	-	-
Pharmacy (n = 24)	-	1 (4.2)	-	-	2 (8.3)	11 (45.8)	-	7 (29.2)	2 (8.3)	-	-	6 (25.0)
Psychology (n = 115)	3 (2.6)	-	-	-	2 (1.7)	1 (0.9)	-	32 (27.8)	-	1 (0.9)	1 (0.9)	-
Social work (n = 27)	2 (7.4)	2 (7.4)	3 (11.1)	-	-	-	-	2 (7.4)	3 (11.1)	-	-	1 (3.7)
Sociology (n = 88)	2 (2.3)	1 (1.1)	1 (1.1)	-	27 (30.7)	1 (1.1)	1 (1.1)	5 (5.7)	5 (5.7)	-	3 (3.4)	-

APPENDIX C

Representative quotes illustrating the themes and subthemes on the extent of integration between the public health curriculum and the 17 first major curricula

Theme	Description of theme	Subtheme	Illustrative quotes from course descriptions
Research methodology	Involves the methods to synthesise new information	Qualitative research methods	*Sociology*: "[. . .] exposes students to the key techniques of qualitative sociological inquiry including interviews, focus groups, content and discourse analysis, archival research, participatory and action research, and various forms of ethnographic research. It further introduces relevant qualitative data analysis and research software tools, in addition to examining the analysis, reporting, and writing of qualitative research." (Course Code: SC3221)
		Quantitative research methods	*Geography*: "Methods and considerations are introduced with case studies for mapping population and health data, quantifying spatial patterns and detecting spatial clusters in health events, measuring exposure to risk factors, and evaluating spatial accessibility to health care." (Course Code: GE4241 / GE4241HM) *Pharmacy*: "Apply basic statistical concepts in data analysis." (Course Code: PR1153) *Psychology*: "Covers [. . .] inferential statistical techniques." (Course Code: PL2131) / "[. . .] gain confidence in using R programming language for data exploration and statistical analysis." (Course Code: PL2132) / "Skills in statistical programming, data exploration and data analysis in R." (Course Code: PL4245)
Factors influencing human health and disease	Involves factors that affect human health and disease	Mental factors	*Psychology*: "This core module covers most of the common mental health difficulties identified for children and adults, e.g., anxiety, depression, stress, anger, behavioural problems, attention deficits, psychosis, personality disorders, substance abuse, and suicide."(Course Code: PL3106)
		Physical factors	*Life Sciences*: "It focuses on helping students understand the relevance of epigenetic processes in human physiology (e.g., embryonic development, ageing) and how their mis-regulation underlies diseases such as cancer." (Course Code: LSM3235) *Psychology*: "This includes exploring what ageing means, examining which factors are involved in healthy and pathological aspects of ageing." (Course Code: PL3259)

		Social factors	*Sociology*: "As a comprehensive introduction to medical sociology, this module aims to illustrate that medicine is also a social science. To display the validity of this argument, this module will lead you through an exciting journey, visiting diverse topics such as social epidemiology, social determinants of diseases, experience of illness, social construction of health, medical professions, medical organisations, healthcare systems, and global health." (Course Code: SC2211) / "In spite of a thriving sex industry, many countries continue to criminalise sex work, and these discriminatory laws put workers at risk." (Course Code: SC3229)
Approaches to improving health outcomes	Involves the ways to tackle health issues	Preventive approaches to improving health	*Food Science and Technology*: "[. . .] food constituents may act as dietary antioxidants and anti-inflammatory agents in mitigating the negative effects of oxidative stress and inflammation on development of chronic diseases." (Course Code: FST5301A) *Pharmacy*: "[. . .] introduction to lung cancer screening."(Course Code: PR2154) / "Students learn that preventive medicine is key to reducing serious conditions like cancer, while minor wounds can be managed with appropriate selection of wound care products." (Course Code: PR2156)
		Biomedical approaches to improving health	*Pharmaceutical Science*: "[. . .] fundamental principles behind drug-receptor theory that serve as a foundation for understanding both the drug and the target in drug development." (Course Code: PHS2102) *Pharmacy*: "Relate principles in medical and pharmaceutical microbiology to the etiology of infectious diseases, risk of health product contamination and control of infection." (Course Code: PR1153)
Health delivery	Involves the control of patient flow, the policies, organisation, and delivery of all services dealing with the diagnosis and treatment of disease, or the promotion, maintenance, and restoration of health	Health policies	*Pharmacy*: "Pharmacology and applied therapeutics inform students on clinical decision making and care plan development."(Course Code: PR2154) / "Applied therapeutics and therapeutic drug monitoring will form the clinical bases for effective and safe care plans."(Course Code: PR2155) *Social Work*: "By understanding how and why particular policies develop, students learn to analyse policy and think critically about the use of policy for intervention in the social work profession."(Course Code: SW3220) / "It will first introduce the conceptual framework and context of the formation of healthcare policies."(Course Code: SW3222)
		Health systems	*Pharmacy*: "Explain the key construct underpinning a theory of health behaviour change: the Trans Theoretical Model (TTM) with reference to smoking cessation services." (Course Code: PR2154) / "The socio-economic impact on the use of therapeutic biologics is studied." (Course Code: PR3152)

Sustainability	Involves maintaining or supporting a process over time	Natural environment	*Chemistry*: "[. . .] major challenges of our time such as the destruction of the ozone hole, climate change, indoor and outdoor air pollution, and how to meet growing demands for water and food in the future." (Course Code: CM3261)
		Man-made environment	*Chemical Engineering*: "Cities are likely to determine the future sustainability of the world. If planned and run well, cities are highly liveable and attractive hubs for creative social and economic advancement, sustainability, efficiency, and diversity." (Course Code: EG2501)
Applications and dissemination of data	Involves application of quantitative and qualitative data, as well as data communication	Data analysis	*Data Science and Analytics*: "[. . .] introduction to data storage systems, data manipulation, exploratory data analysis, dimension reduction, statistical graphics for univariate, multivariate (high-dimensional), temporal and spatial data, basic design principles and critical evaluation of visual displays of data." (Course Code: DSA2101)
		Data visualisation	
		Data modelling	*Business Administration*: "Quantitative models and tools such as Decision Analysis, Simulation Modelling and Mathematical Optimization are covered to demonstrate the use of scientific methods in business decision making." (Course Code: DAO1704)
		Data communication	*Psychology*: "'Effectively communicating scientific findings in both oral and written formats." (Course Code: PL3281)