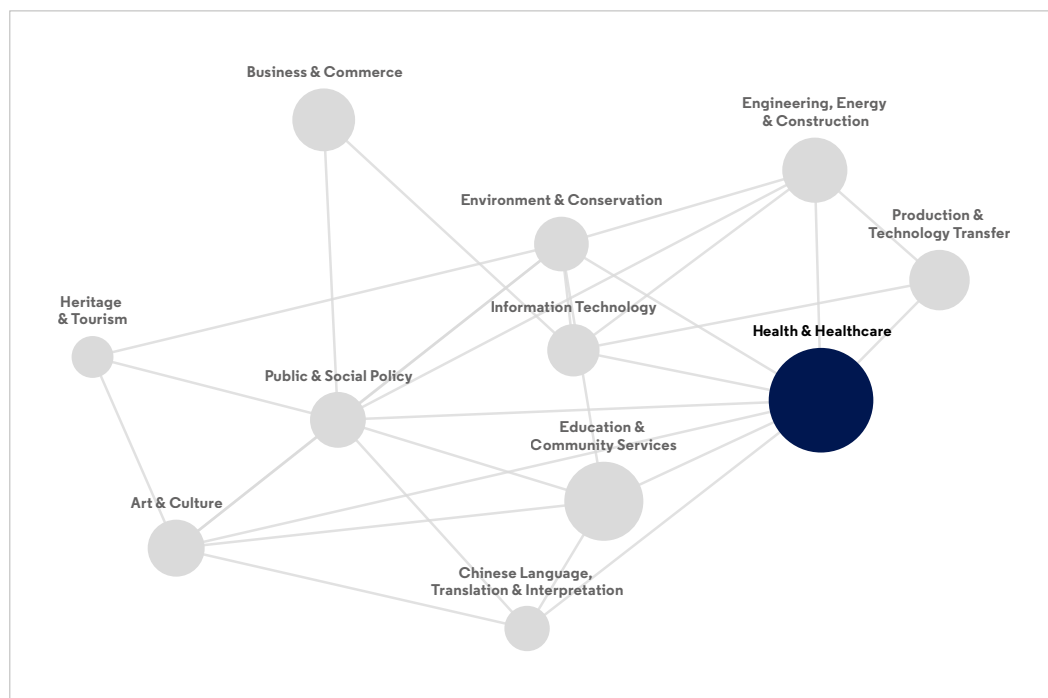




The societal impact of research undertaken by Hong Kong universities:

Health & Healthcare

A synthesis of the RAE 2020 impact case studies



Partnered with:



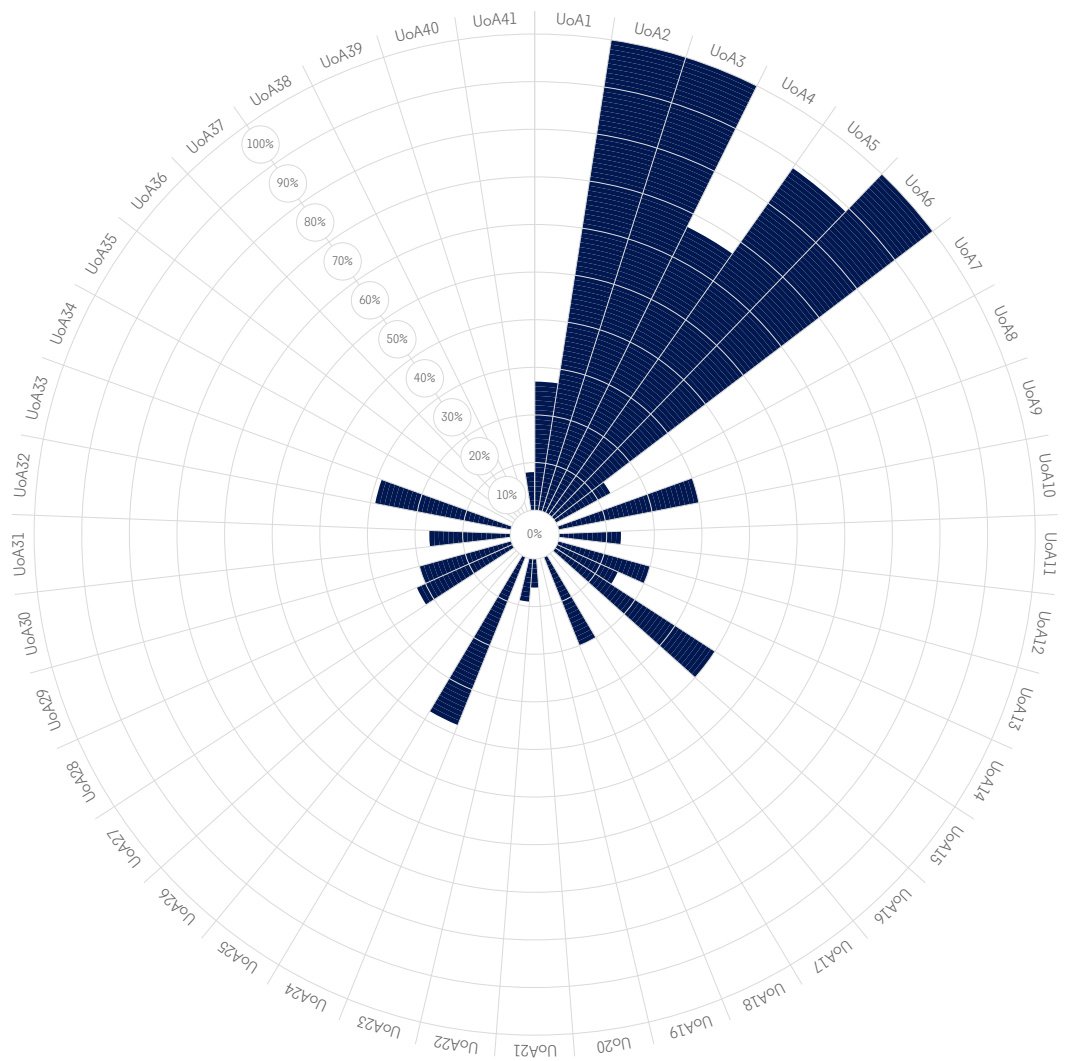
This report is part of a series of outputs that examines the impact of research arising from eight universities based in Hong Kong and funded by the University Grants Committee (UGC). The report focuses on the Impact Case Studies (ICS) produced by the UGC-funded universities as part of their response to a Research Assessment Exercise (RAE) in 2020. The overarching report - *The impact of research undertaken by universities in Hong Kong: A synthesis of the RAE 2020 impact case studies* – is accompanied by 11 thematic reports that examine the nature of research impact in different areas, ranging from Arts & Culture to Health & Healthcare. The 342 impact case studies that are analysed through this body of work are also available on a searchable database that is posted on the UGC’s website.

The Health & Healthcare cluster contains 64 impact case studies (ICS) from nine primary topics identified in the topic modelling.¹ The Health & Healthcare cluster is the largest analysed, representing 19% (i.e. 64/342) of ICS submitted to RAE 2020.

The impact wheel in Figure 1 illustrates how the Health & Healthcare cluster is distributed across the 41 Units of Assessment (UoAs) used for RAE 2020. All of the ICS for UoA 2 (pre-clinical studies), UoA 3 (clinical medicine), and UoA 6 (Chinese medicine) were included

in this cluster along with the majority (i.e. over 50%) in UoA 4 (clinical dentistry) and UoA 5 (nursing, optometry, rehabilitation sciences and other health care professions). Of significant interest is the contribution non-health related UoAs make to the health and healthcare cluster including UoA 24 (psychology, three ICS), UoA28 (social work and social policy, two ICS), and one each from UoA 21 (economics and finance) and UoA 22 (business). In fact, the Health and Healthcare cluster had the broadest contribution of UoA across the eleven themes examined, with 21 of 41 UoAs making a contribution.

Figure 1: Impact wheel for the Health and healthcare theme (n=64)



¹ See methodological annex for details.

The impact of Hong Kong universities' research: **Health & Healthcare**

Table A shows the most salient features of the case studies in terms of beneficiaries, location, type of impact and time lag. It gives the percentage of case studies in this cluster that were tagged with sub-codes under these code headings, as well as the percentage of case studies tagged with those sub-codes in the entire sample of 342.

The 64 case studies in this cluster benefited three key sectors under the classification of the Hong Kong Standard Industrial Classification: not surprisingly 94% benefited Human health and social work activities with additional contributions to the Manufacturing (16%) and Import/export, wholesale and retail sectors (11%). The key socioeconomic group were patient groups (53%), children (17%), and women and gender-based groups (9%). The key decision taker groups that were involved were government departments/agencies (34%), the private sector (25%) and NGOs/ third sector (23%). Beyond Hong Kong (70%), the Greater Bay Area (2%) and Mainland China (16%), these case studies primarily had an impact in the United States (55%) and the United Kingdom (27%). The most salient type of impact was informing procedure, practice or protocol (64%), followed by informing guidelines or strategy (41%), patents (27%) and job generation (20%). On average, the research in this cluster started in 2005, compared to 2006 for the whole sample. The median publication date for this cluster was 2015, mirroring the whole sample (2015).

On reading the ICS in the Health & Healthcare cluster it was evident that they could be grouped into a number of different subthemes that impact on different disease areas, as summarised in Table 1. Several case studies described a classic 'bench to bedside' pathway including around drug development, underpinning clinical guidelines, protocols and procedure, the development of diagnostic tests or the introduction of screening programs. A second group of cases focused on different conditions or disease types – for example infections disease or mental health. Chinese and herbal medicine – including issues around safety – formed another interesting subtheme, whilst there was also a group of ICS that illustrated how other disciplines can impact on health in unexpected ways – for example the development of a camera system for space exploration being used in surgery. Clearly there are many ways to group these case studies but on pages 6, 7, 8 and 9 the taxonomy draws out some of the interesting and unexpected ways that research has improved the health and health care of people in Hong Kong and globally.

Table A: Some salient features of research impact identified in the Health & Healthcare cluster (n = 64)

Beneficiaries of impact (top mentions)	% of <u>cluster</u> impact case studies	% of <u>all</u> impact case studies
Hong Kong Standard Industrial Classification		
Human health and social work activities	94%	34%
Manufacturing	16%	9%
Import/export, wholesale and retail	11%	8%
Sociodemographic group		
Patient groups	53%	12%
Children (under 18)	17%	20%
Women and gender-based groups	9%	4%
Decision taker group		
Government departments/agencies	34%	31%
Private sector	25%	30%
NGOs/third sector	23%	17%
Location of impact		
	% of <u>cluster</u> impact case studies	% of <u>all</u> impact case studies
Hong Kong	70%	75%
Greater Bay Area (excluding Hong Kong)	2%	3%
Mainland China (excluding Hong Kong and GBA)	16%	12%
United States	55%	32%
United Kingdom	27%	17%
Type of impact (top mentions)		
	% of <u>cluster</u> impact case studies	% of <u>all</u> impact case studies
Inform procedure, practice or protocol	64%	52%
Inform guidelines or strategy	41%	27%
Patent	27%	15%
Job generation	20%	11%
Elapsed time		
	<u>Cluster</u>	<u>All</u>
Median year of research commencement	2005	2006
Median year of publication date	2015	2015

Table 1: Diseases, conditions and syndromes mentioned in one or more of the health and healthcare ICS

Adolescent mental health	Mental health
Alzheimer's disease	Middle East Respiratory Syndrome (MERS)
Bleeding peptic ulcers	Myopia
Breast cancer	Osteoporosis
Cervical cancer	Prostate cancer
Diabetes	Psychosis
Down Syndrome	Reproductive health
Eating disorders	Scoliosis
Hepatitis B	Severe Acute Respiratory Syndrome (SARS)
Induced liver injury	Sleep deprivation
Influenza	Smallpox
Liver fibrosis	Suicide prevention
Lung cancer	Tooth decay
Malaria	

Drug development, underpinning clinical guidelines, protocols and procedure, the development of diagnostic tests or the introduction of screening programs

One excellent example of how Hong Kong researchers have supported drug development with a global impact comes from a team at The University of Hong Kong. It is estimated that chronic hepatitis B infection affects 257 million individuals and causes 880,000 liver-related deaths annually in the world. The standard treatment for hepatitis B used to be a drug called lamivudine which, whilst effective, was prone to a high level of viral resistance in patients over time. The team at The University of Hong Kong investigated and tested an alternative drug, entecavir, and showed that it was superior to lamivudine in terms of both effectiveness and lower rates of resistance. Today, entecavir is recommended for the treatment of hepatitis B in clinical guidelines globally and was added to the WHO essential list of medicines in 2015. Another example includes the development

of a number of anti-cancer drugs by a team at The Hong Kong Polytechnic University that are in various stages of clinical trials. These have received in excess of US\$40m of investment from pharmaceutical companies with one of the drugs being licenced for US\$5m. The research team estimate that 30 jobs have been generated locally as a result of these investments, demonstrating that whilst no clinical impact on patients can be measured at this early stage, the activity of drug development in itself can generate an economic benefit. A final example of drug development can be dated back to 1988 when the key researcher began his PhD, looking at a type of receptor antigen (5-HT₃) which seemed to reduce nausea and vomiting in cancer patients receiving chemotherapy. The researcher dedicated his career to this line of work over 30 years,

leading to the discovery and development of drugs that reduce nausea and emesis, permitting an improved quality of life, a more effective use of anticancer treatments and better survival rates for cancer patients. It is important to note, again, that whilst this ICS follows a classic ‘bench to bedside’ path it also illustrates the extended time-line between initial research and societal impact.

In addition to drug development, a number of ICS developed diagnostic tests. One example, is an innovative test for liver fibrosis. In the past, patients had to undergo invasive liver biopsy examinations in order to assess the severity of liver fibrosis. As a liver biopsy examination may cause complications and patient discomfort, patient uptake is relatively low and this may lead to delays in appropriate treatment. This ICS describes how a research team at The Chinese University of Hong Kong developed Fibroscan, a non-invasive test for liver fibrosis. The test is now widely used as the recommended diagnostic approach in international clinical guidelines. In Hong Kong, as a result of this innovation, the number of liver biopsies has halved over the past 5 years, generating an estimating cost saving of around HK\$13m (cUS\$1.7m) a year.

A further group of case studies focussed on screening programs for a range of disease and conditions including: human papilloma virus; diabetes (and associated complications); and Downs Syndrome. For this last example, a group of scientists at The Chinese University of Hong Kong developed a non-invasive prenatal testing method for detecting foetal chromosomal aneuploidies, e.g. Downs Syndrome. The technology was patented and licenced to a number of companies, is now used annually by over 6 million pregnant women in more than 90 countries (e.g. USA, China, UK, Japan) and has become the new standard of care. Cost-effectiveness evaluation performed in different countries and healthcare settings

affirmed the accuracy and safety of the test which, for example, is now reimbursed by major medical insurance companies in the USA. On 1 April 2017, Belgium became the first country to offer full medical coverage for cell-free DNA based prenatal screening of fetal chromosomal aneuploidies to all of its citizens.

Disease specific example of impact

The previous group of ICS describe the diverse pathways to impact. Another lens through which to view such research is by disease area. More than 25 different diseases were mentioned in the 64 ICS in the Health & Healthcare theme (Table 1). One specific area of contemporary relevance was the number of ICS that focussed on research on viruses including influenza, SARs and MERS. For example, a team from The University of Hong Kong’s Department of Microbiology were the first to confirm that live poultry markets were the source for influenza A(H7N9) in humans (colloquially ‘bird flu’). The closure of live poultry markets was shown to reduce the number of infections by 97-99% in various cities in Mainland China. Another ICS from the same department describes how these scientists were the first to identify the novel coronavirus that resulted in the SARS epidemic of 2002-2003. Using this knowledge, several companies were able to develop rapid diagnostic tests contributing to both the management of the epidemic and revenue generation.

In an unrelated area, a team from The Hong Kong Polytechnic University developed novel contact and spectacle lenses (known as ‘dual power lenses’) and evaluated their efficacy in controlling myopia progression in schoolchildren. They showed that they were highly effective in slowing the development of this condition.

The team went on to patent and licence the lenses for production. By August 2019, c.130k had been sold in Hong Kong and Mainland China. A similar story was told for another ICS focused on tooth decay. Here the research team – from The University of Hong Kong - was pivotal in developing the use of silver diamine fluoride (SDF) solution to manage tooth decay in children. The research led to the establishment of an oral health programme that served more than 170,000 preschool children in Hong Kong between 2010 to 2019, with around 70% of the decay in 24,000 decayed primary teeth treated annually with SDF becoming inactive.

A number of ICS focused on mental health and well-being. For example, one ICS describe how a team of researchers from The Chinese University of Hong Kong had improved mental health service for children and adolescents by ‘re-norming’ a number of clinical assessment tools and protocols that had been developed in the West. The team reviewed, validated and amended a series of protocols for the assessment and diagnosis of mental disorders amongst young people. They estimated that about 10% of all 6-17 year-olds now use the updated protocols at some point in their adolescence. In a similar vein, a researcher at City University of Hong Kong, developed instruments for measuring the cognitive style of ‘hope’, an important psychological attribute in goal setting. As with the previous ICS, the tool needed to be adjusted to respond to the regional cultural context and resulted in the Chinese Adult Hope Scale and the Chinese Children Hope Scale. The Chinese hope scales are now used by occupational therapists and psychiatric nurses in four major hospitals in Hong Kong as well as practitioners and researchers in Mainland China, Taiwan and Macau. On the back of developing the hope scales, the researcher then went on to develop material that would increase hope through the use of stories. These were proved to be effective and are again widely used in the region. For example, the team helped social workers develop a Chinese hope storybook for parents of children with special needs. The 4,800 copies of the book that have been published have benefited over 15,000 families.

Chinese and herbal medicine

A set of ICS focused on Chinese medicine and the synergies between eastern and western approaches to health. For example, two ICS – one from a team of researchers from The Chinese University of Hong Kong and another from Hong Kong Baptist University – were among the founding research institutes for the establishment of the Hong Kong Chinese Materia Medica Standards (HKCMMS). These standards are important because the natural ingredients on which Chinese medicines are based often have similar appearance and can easily be confused. As a result, there are examples where consumers of Chinese medicine have been poisoned due to mistaken herbal drug identities. These projects helped increase awareness among the Chinese medicine sector regarding quality and safety, as evidenced by the significant decrease in the cases of poisoning. Another team at The Chinese University of Hong Kong used DNA technology to authenticate herbal materials, an approach then adopted by companies that supplied Chinese and herbal medicines.

A slightly different example came from The University of Hong Kong, where a team of researchers developed a new Integrative Body-Mind-Spirit (IBMS) intervention to promote holistic wellness for those confronted by health and mental health challenges. The approach was grounded in Eastern philosophies and Chinese medical practices and was shown to be effective in areas including cancer care, mental health, chronic disease management and reproductive health. The team trained social workers and healthcare professionals to integrate IBMS into service delivery systems in Hong Kong, Taiwan, Singapore, USA and India. The Hong Kong Jockey Club drew on this work to support an End-of-Life Community Care project between 2016 and 2018 that developed an IBMS community end-of-life-care model via four community service organizations and two universities. This project reached 9,400 healthcare and social service professionals, 3,700 patients and family members, and more than 350,000 people through public education.

Transdisciplinary impacts on health and healthcare

As noted above there were valuable case studies where research in a discipline not apparently related to health or healthcare nevertheless impacted on this area. Research undertaken by a team of engineers at The Hong Kong Polytechnic University (submitted to UoA14: mechanical engineering, production engineering, incl. manufacturing & industrial engineering) underpinned a camera pointing system used by the Chinese National Space Administration in its Chang'e-3 and Chang'e-4 missions to the moon in 2013 and 2019 respectively. The technology was transferred to NISI (HK) Ltd., a start-up that raised sufficient investment to now employ over 140 staff. NISI has gone on to develop a new robotic system for minimal/non-invasive surgery. The camera pointing system's materials' properties, design and mechatronics have been applied

in creating a reduced-size, light-weight and high-precision robotic system, both smaller than current commercial systems and capable of providing tactile feedback.

Another example, from UoA18 (planning and surveying), described how a group of researchers from the Faculty of Architecture at The University of Hong Kong developed Spatial Design Network Analysis software to generate evidence for more pedestrian and walking-oriented space in urban design. The software has been widely used by transport consultants across the world: one novel application was its use by the UK Biobank project based at Oxford University to develop innovative objective and standardised built-environment indicators for epidemiological studies. The UK Biobank contains biological and social data of over 500,000 people and is a unique resource for understanding gene-environment interactions. The development of standardised built-environment indicators is key to develop such research.

The characteristics and translation of the underpinning research

Table B provides the salient features of the underpinning research. It provides bibliometrics as well as information on the impetus for the research and mechanisms/channels of dissemination.

413 outputs from this cluster are indexed on the Web of Science, which have a mean citation score of 7.16. This is substantially higher than the mean of 4.45 for the whole sample, likely due to high citation patterns in medical and health fields. The median citation score is 1.90, which is higher than the median of 1.59 for all case studies. Key international collaborators included the United States (21%), the UK (11%), and Australia (6%).

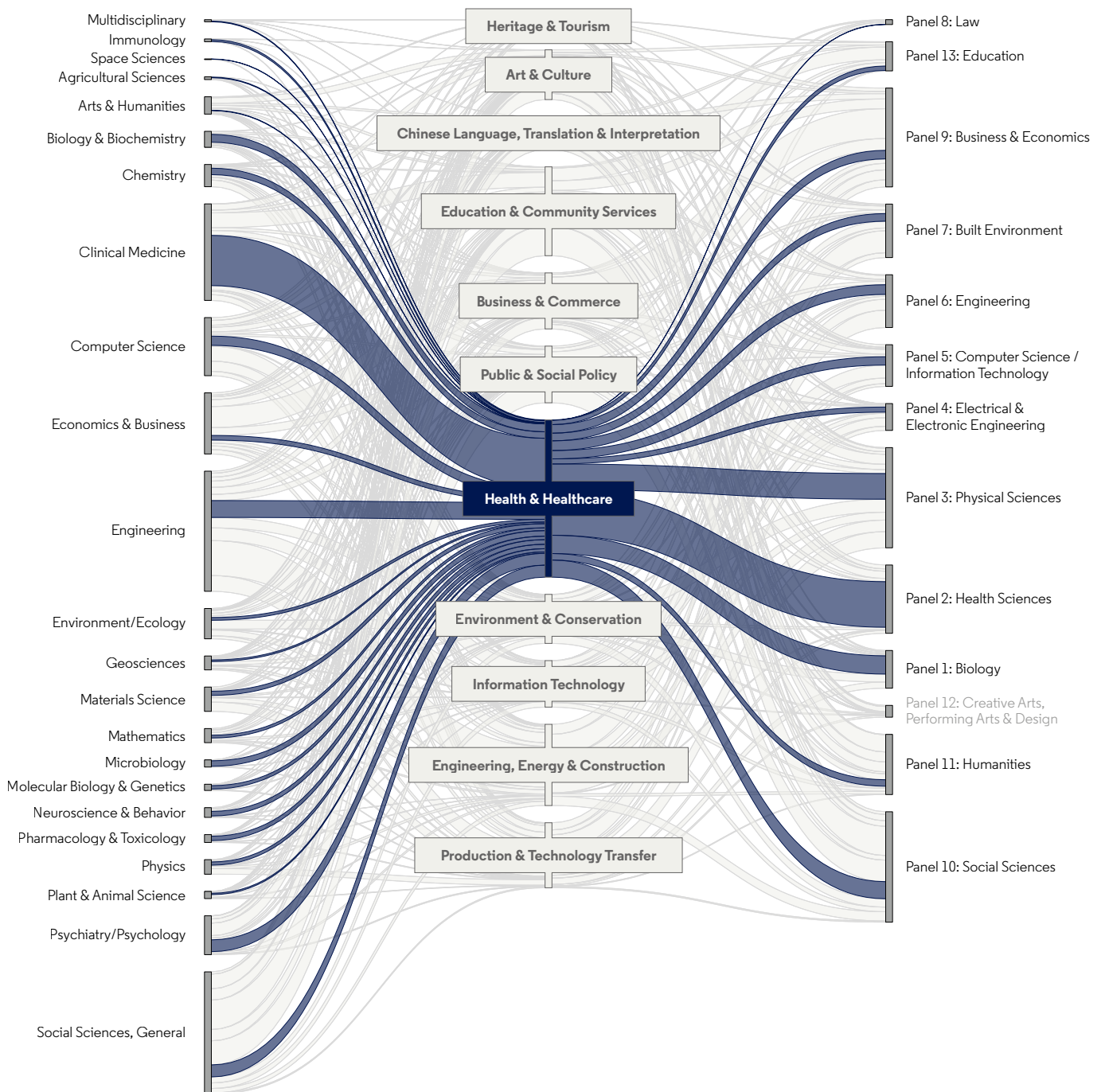
8% of the research in this cluster was driven by a demand for better innovation and technology, while 6% was driven by demand for better protocols, practices, or policies. The main forms of co-production and collaboration were academic and industry partnership (20%) and academic and public sector partnership (14%). The researcher was involved in the impact by being referenced as an expert or advisor (20%) and by through collaboration with the sector (8%). The research findings were disseminated primarily media coverage (36%) and educational and training materials (36%). The research was patented (33%) and gained recognition through prizes and awards (25%).

Table B: Some salient features of the underpinning research identified in the Health & Healthcare cluster (n = 64)

Analysis of underpinning research	<u>Cluster</u> impact case studies	<u>All</u> impact case studies
Bibliometrics indicators		
Number of outputs indexed on Web of Science	413	1445
Mean citation score	7.16	4.45
Median citation score	1.90	1.59
Collaborators location (top mentions, excluding China)		
USA	21%	18%
UK	11%	8%
Australia	6%	5%
Impetus for research (top two mentions)	% of <u>cluster</u> impact case studies	% of <u>all</u> impact case studies
Pull factors		
Demand for better innovation & technology	8%	11%
Demand for better protocols/practices/policies	6%	8%
Push factors		
External advances creating new questions	13%	6%
Follow on from research team's previous work	13%	12%
Mechanisms/channels of impact (top mentions)	% of <u>cluster</u> impact case studies	% of <u>all</u> impact case studies
Coproduction & collaboration		
Academic - industry partnership	20%	23%
Academic - public sector partnership	14%	17%
Researcher involvement		
Referenced as expert, practitioner or adviser	20%	33%
Collaboration with sector	8%	20%
Dissemination of research findings		
Media coverage	36%	48%
Educational and training materials	36%	32%
Codification of impact eg prizes, patents etc.		
Idea/product patented	33%	11%
Prizes and awards	25%	33%

The alluvial diagram in Figure 2 links the underpinning research (as classified by discipline using the 23 Web of Science, Essential Science Indicators (ESI), journal categories) to the 11 clusters identified through the topic modelling and the 13 Panels used in RAE 2020. The Health & Healthcare cluster has been highlighted, with the impact pathways for the other clusters greyed out. Figure 2 illustrates the multidisciplinary nature of research impact; each of the journal categories feed into the cluster and the cluster contributes to ICS submitted to all RAE panels except for Panel 12: Creative Arts, Performing Arts and Design.

Figure 2: Alluvial diagram linking underpinning research with clusters and panels.



Methodological annex

This synthesised impact report presents a cross-cases analysis of the salient features in 342 impact case studies (ICS) provided by Hong Kong universities as part of the RAE 2020 evaluation. A sequential multi-method approach was employed. The first component involved quantitative topic modelling, followed by directed content analysis. This approach allowed the essence of the impact generated by Hong Kong universities to be captured and synthesised. It is important to note that the analysis and conclusions of these reports are based on the impact as described in the ICS. That is, the authors of this report took the case studies at face value and did not verify or question the narratives provided. A summary of the methodology is given below. For more detailed information on the methodological elements of this study, please see the overarching impact report.

Quantitative topic modelling

Quantitative topic modelling was used to identify overarching topics in the ICS. Topic modelling is a language processing technique applied to document sets to understand the different combinations of words or phrases (topics) that are present. It is a data driven approach, meaning results are not dependent on pre-conceived notions of structure, but are instead derived from the data itself.

Python, Scikit Learn, and Gensim packages were used to implement the topic modelling. Text from section 4 (Details of Impact) from the ICS was normalized (i.e. removal of punctuation and special characters), and domain specific stop-words were removed (i.e. words that are used frequently across the case studies). Various implementations of

the topic modelling algorithm were tested, and the Non-negative matrix factorization [NMF] was found to produce the most usable results. After testing multiple models using this algorithm, and manual review by the authors, the number of topics was set to 35 to provide a balance between the breadth of groupings and granularity of topics.

In discussion with UGC, the research team developed an initial taxonomy by grouping similar topics into broader 'clusters'. For example, the topics 'finance', 'accountancy and governance', and 'economics' were grouped into a cluster titled 'business & commerce'. Topic clusters were set at the outset of the analysis to ensure cognitively similar cases were read together, thereby improving the quality of coding, analysis, and impact reports. This classification system then informed the coding and testing of case studies.

Directed content analysis

Qualitative directed content analysis was then used to elucidate the salient characteristics of the impact narratives. This involved an iterative process of examining case studies and developing a code book to categorise their inherent features. The code book was derived from the existing literature and the domain expertise of the authors. It included four overarching categories: a) research, which captured funding source and impetus for research; b) time lags, which captured the elapsed time between the research and its impact; c) mechanisms/channels of impact, which included forms of collaboration and dissemination; and d) impact, which included beneficiary groups (e.g. young people, women, ethnic minorities), location and reach (e.g. Hong Kong, Mainland China, elsewhere), and the nature of impact (e.g. commercial, policy, practice).

Using the cloud based qualitative analysis software, Dedoose, each case study was read, and relevant excerpts were 'tagged' with the relevant codes. Multiple codes

and subcodes were attributed to individual case studies. This allowed all case studies that had been tagged with a particular code (e.g. a particular beneficiary group) to be considered as a group. Two of the study's authors undertook the reading and coding (JG and KW). Inter coder reliability was ensured by double coding 10% of the cases (i.e. each author codes the same case study) and through regular coding meetings that were used to compare code applications and adjust the code book as required. The code book was thus a 'living document' that was reviewed and revised iteratively. This process allowed for cross case analysis that was the basis of synthesised impact reports. A code co-occurrence matrix was used to identify where the overarching codes intersect (for example, instances where particular topics are associated with particular beneficiary groups). The properties of the ICS were systematically examined, and evidence was gathered by assigning segments of text to unique codes within the broader coding categories. This process allowed for cross case analysis that formed the basis of this synthesised impact report.

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