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INTERNATIONAL PERSPECTIVES

Effects of Artificial Intelligence and Robotics on Human Labour: A Systematic Review

Abstract: This systematic literature review paper, written by **Channarong Intahchomphoo**, **Jason Millar**, **Odd Erik Gundersen**, **Christian Tschirhart**, **Kris Meawasige** and **Hojjat Salemi**, examines academic research publications to learn about the effects of artificial intelligence (AI) and robotics on human labour. Papers were collected from three academic databases: Scopus, Web of Science and ABI/INFORM Collection. From 710 papers, 159 papers were included. The article finds that the effects of AI and robotics on human labour can be categorised as: (i) positive effects, (ii) negative effects, and (iii) neutral or unsure effects. The positive effects have five reasons regarding AI and robotics' potential to: do dangerous work, do tedious work with high efficiency and accuracy, do some aspects of computing work, do work that human labour does not want to do and be used to deal with the labour shortage, and help to reduce business production and maintenance costs. The negative effects are based on two reasons, that AI and robotics will take over human labour in part or entirely, thereby creating unemployment crises, and will not only replace manually repetitive jobs from human labour but also cognitive jobs, causing human labour to fear that their jobs will be replaced by AI and robotics. The neutral and unsure effects are based on various unique arguments. The findings of this review are used to suggest future research for academic communities and practical recommendations to legal professionals and policy makers.
Keywords: Artificial intelligence; Robotics; Human labour; Systematic literature review

1. INTRODUCTION

The purpose of this systematic literature review is to establish the current state of knowledge in the academically indexed literature on the effects of AI and robotics on human labour. The use of AI and robots in the workplace in various industries is often referred to as the "fourth industrial revolution" and this is an era we are living in.[1] Increasingly, human labour has to share their workplace or work collaboratively with AI and robotics. Therefore, it is important to conduct this review to better understand the automation and the future of human work. Also, in the past several decades, AI and robotics technologies have rapidly and qualitatively advanced in numerous ways, including ChatGPT, the latest text-based generative AI by OpenAI launched in November 2022. As such, there will be many effects and changes that will directly and indirectly impact human labour. Some jobs may change, and some may vanish. Based on our search of databases, to date on February 2022, there is currently no systematic literature review documenting the effects of AI and robotics on human labour.[2]

The structure of this review consists of the following sections. Section 2 contains the methods of this review. It describes data sources, search strings, selection criteria, and the included and excluded studies. Section 3 presents the results of the included studies and how they answer the review question. Findings are presented based on thematic similarity. Section 4 includes our discussion and suggestions for future research and practical recommendations for legal professionals and policy makers. Section 5 consists of the conclusion and limitation of this review.

2. METHODOLOGY

REVIEW QUESTION

- What are the effects of artificial intelligence and robotics on human labour?

DATA SOURCES AND SEARCH STRINGS

Three academic databases were used to search for scholarly publications for this review: SCOPUS, Web of Science, and ABI/INFORM Collection. Authors accessed the databases via the University of Ottawa Library, Canada. SCOPUS houses academic collections in many subject areas, whereas the Web of Science contains research publications in engineering and pure and applied sciences. ABI/INFORM Collection is known for having human resource management and business administration publications. The variety of subject content in these repositories is important because we wish to retrieve information from interdisciplinary sources in order to find a variety of viewpoints. Authors performed title and abstract searches in all three selected databases on the same day, (February 1, 2022), with the same search strings (Figure 1). The search expression was designed around three main concepts: artificial intelligence, human labour, and effects. The terms of machine learning and deep learning (a structured machine learning technique) were also included because they are currently heavily used in designing AI algorithms. Abbreviations and synonyms of the three concepts were also included. The Covidence web-based software platform was used to streamline the production of this review including citation screening, abstract and full-text review, and extraction and export of data and references.[3] This platform was used through the University of Ottawa's institutional subscription.

SELECTION CRITERIA

The criteria for selecting the primary studies to be included in the sample and subsequently analysed included type of publication, date of publication, relevance to the review question, language, subject, and duplicates, as detailed below.

Type of publication: The studies must have been published in peer-reviewed journals or conference proceedings. The content also had to be available in full text format. The criterion of peer-review offers some level of quality control, as does the fact that they are indexed in SCOPUS, Web of Science or ABI/INFORM Collection.

Date of publication: The studies must have been published between January 2011 to February 2022, the time this review was conducted. The date of publication parameters is due to the many new AI and robotics technology developments in the past 10 years.

Relevance to the review question: The studies must be relevant to the review question. Queries in a search engine only retrieve documents that contain the search terms and the presence of a term or even a combination of terms is not a sufficient condition for the relevance of the study to the research question. The relevance of a study must be evaluated by a human reviewer, which is completed by reading the article, starting with abstract screening and then full-text screening.

Language: The studies must have been written in English.

Subject: Studies could come from any academic discipline so there is no constraint in this area. The absence of disciplinary constraints ensures that the search expressions retrieve as many relevant articles as possible (maximum recall). Furthermore, academic discipline should not be restricted as research on this question spans multiple disciplines.

Duplicates: If the searches on SCOPUS, Web of Science and ABI/INFORM Collection produced duplicate results, only one occurrence of the document would be counted.[4]

INCLUDED AND EXCLUDED STUDIES

Figure 2 details the total records identified from each of the three databases searched, records removed due to duplication, wrong type, date or language, articles screened for eligibility and removed, leading to the final total of 159 studies included in this literature review.

3. RESULTS

Included studies were clustered according to thematic similarity. The findings indicate that AI and robotics affect human labour in three ways: (i) AI and robotics create positive effects for human labour mainly by supplementing human labour in the workplace, (ii) AI and robotics create negative effects by replacing human labour in the workplace, and (iii) AI and robotics create neutral or unsure effects.

3.1 AI AND ROBOTICS CREATE POSITIVE EFFECTS FOR HUMAN LABOUR

AI and robotics create positive effects for human labour mainly because they supplement human labour in the workplace and reduce workplace risks. This phenomenon creates

> (("artificial intelligence" OR AI OR robot OR robots OR robotics OR "machine learning" OR "deep learning") AND ("human labour" OR "human labour" OR "human work" OR "labour of man" OR "labour of man" OR "work of human" OR "work of man") AND (effect OR effects OR impact OR impacts OR consequence OR consequences OR outcome OR outcomes OR result OR results))

Figure 1: Search strings designed for this systematic literature review

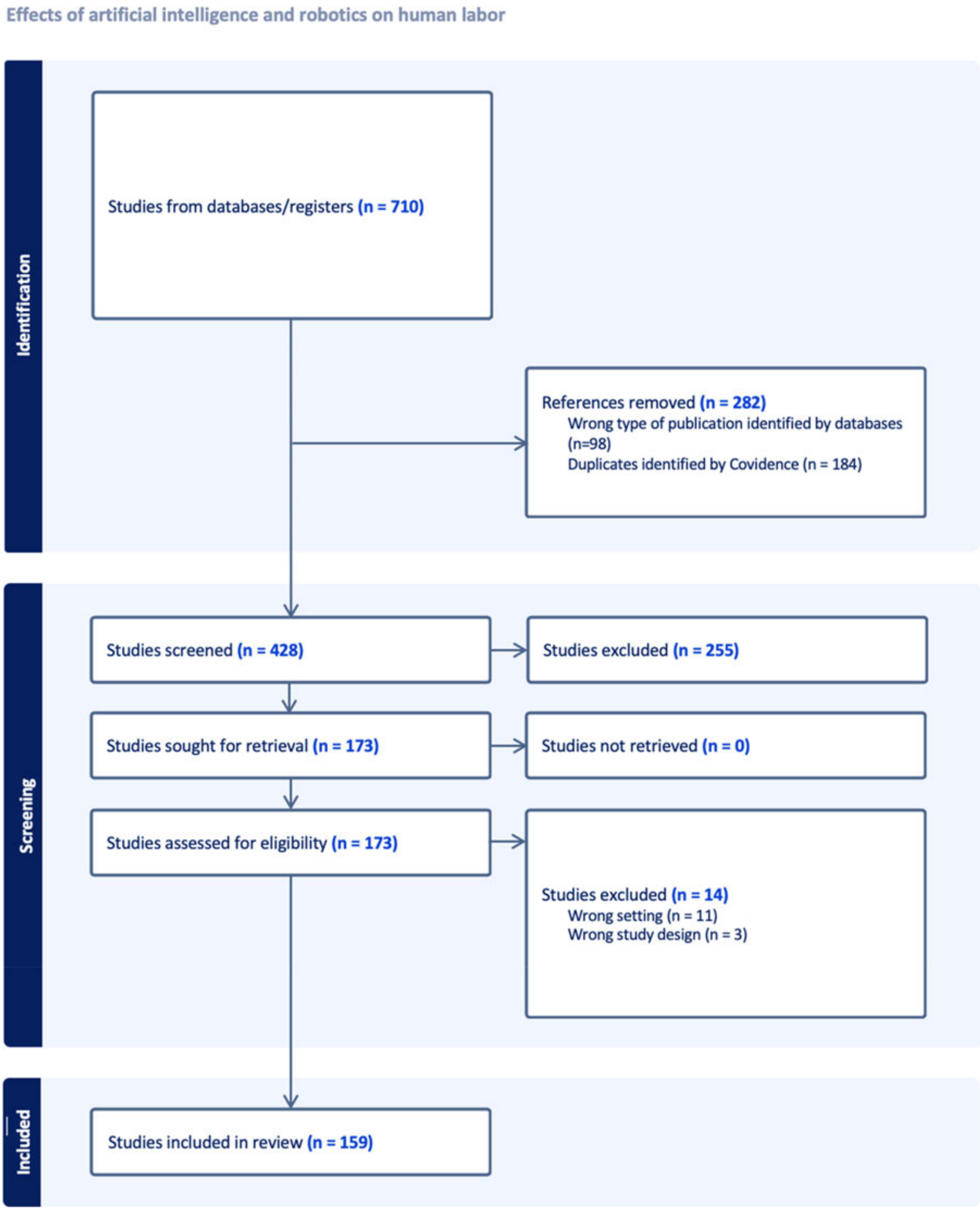

Figure 2: Studies identified by the search strings and selection criteria

a new collaborative work between human labour and AI and robotics. The following are the reasons and examples as to how AI and robotics create positive effects for human labour.

AI AND ROBOTICS COULD DO DANGEROUS WORK

In our sample, 24 papers discuss how AI and robotics could do dangerous work. They are used to supplement human labour, because the workplaces are dangerous, hazardous, or in harsh environments and often with high chemical usage, particularly in manufacturing factories.[5,6] Human labour's safety is put in jeopardy.[7] Examples include iron and steel manufacturing where they use chemicals and high temperatures in the production, but now AI and robotics systems can detect and classify surface defects of the metal. This task was previously performed by human labour exclusively.[8] Now there are robotic forklifts, hands, arms, and grippers that can lift large or heavy items, and they can handle general goods, waste disposal, and also chemical hazards and toxic substances

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in factories.[9,10,11] Automotive and electronics manufacturing also have robots doing work such as welding, deburring, grinding, printing, and assembling.[12,13,14] Those examples demonstrate how, in some cases, AI and robotics liberate human labour by doing dangerous tasks while at the same time helping to improve and protect the health of human labour and by this increasing both safety and efficiency.

There are similar uses of AI and robotics in high risk workplaces including in the oil and gas sector,[15] in agriculture where spraying pesticide and insect repelling tasks are involved,[16,17] in fish-processing plants where human labour need to be very careful about bacterial contamination spoiling the foods, so using AI and robotics in the cleaning system is much better because they help to minimise contamination,[18] and in waste management activities where AI image recognition systems are able to classify and monitor garbage, while also reducing human labour needed for dirty recycling and waste disposal tasks.[19]

Furthermore, AI and robotics are used to supplement human labour in dangerous infrastructure maintenance and inspection. Robots are made to clean glass façades and windows of high-rise building instead of human labour[20,21] and are also used to maintain building exterior walls and detect faulty pipelines and ceilings.[22,23] AI and robotics systems can also do work like underwater manipulation tasks when installed in remotely operated underwater vehicles in maritime industry.[24]

Beyond the dangers in workplaces mentioned above, AI and robotics are being used to help humans in rescue missions.[25] After catastrophic situations like a tsunami, disaster assistance robots are used in the search and rescue process when it is still too risky for human rescuers to do the work. Moreover, robotics drones are used to collect aerial data to plan the rescue place and locate obstacles in the water and on the land.[26,27] During the Covid-19 pandemic, several AI and robotics tools were created to work on tasks in diagnosis, screening, disinfection, surgery, telehealth, patient care, logistics, manufacturing, and others because they could not be infected and spread the virus, unlike the human health workers.[28]

AI AND ROBOTICS COULD DO TEDIOUS WORK WITH HIGH EFFICIENCY AND ACCURACY

In our sample, 33 papers discuss how AI and robotics can do tedious work. They can handle tedious works to supplement the limited physical capacities of human labour. Tedious work includes tiring, time-consuming, labour-intensive, and repetitive tasks.[29,30] Over a certain period, those tasks will be at risk of error-prone situations and can lead to inconsistency of work, and subsequent damages could be costly to a given company. Examples of AI and robotics doing tedious work with high efficiency and accuracy includes: cleaning spaces,[31] AI algorithms evaluating credit risk,[32] AI in the document processing automation in the financial and accounting industry,[33] AI in large scale land-use mapping of the Guangdong Province of China,[34] AI technology in the fault diagnosis of rotating machinery tested with centrifugal pump and motor bearing (a time-consuming and labour-intensive task if performed by human labour),[35,36,37] AI in product quality inspection on a production line i.e., ball bonding inspection in the manufacturing process of semiconductor devices and integrated circuits – a task impossible for human labour to always perform accurately because of eye-fatigue and other health conditions[38,39] – while AI and robotics are also being implemented in inspection of finished metal surfaces in the lapping and levelling process.[40] For infrastructure maintenance, AI and robotics could efficiently inspect the condition of sewer pipeline systems, detect potholes on streets and other types of road damage and detect defects in pipeline and concrete structures. Importantly, AI advancement is getting better at doing highly complex inspection and maintenance management tasks.[41,42,43,44,45,46]

In the academic community, AI is being developed to review research papers submitted to journals and conferences, as the manual review process is time-consuming.[47] In the agricultural sector, AI with image processing ability is used to classify apples and other fruits and sort them automatically based on their skin colour, determining maturity and ripeness,[48,49] classifying hazelnut varieties,[50] and monitoring for whiteflies in tomato greenhouses.[51] In medicine, AI and robotics are made specifically to do tedious work that requires processing a large number of medical records in a short amount of time (i.e., AI classification of patient records with thyroid conditions),[52] AI is employed in the sending and retrieving of surgical instruments during the patient operation process, tasks normally done by nurses,[53] and AI is used for screening diabetic retinopathy from retinal images as it takes less time for AI to process the data and millions of people need to be screened for diabetes.[54] In the retail sector, AI systems are installed on shopping carts to detect and monitor for out-of-stock products and process refill orders.[55]

Beyond the ability of AI and robotics to do tedious works, there is also the ability to perform tasks with higher efficiency and accuracy than human labour in terms of scale, speed, and self-learning. For example, AI analyses the development of corrosion in pipe systems reducing the need for engineers to engage in repetitive tasks,[56] automotive plants use AI to diagnose technical failures, anticipate maintenance needs, and order replacement parts,[57] and AI and robotics systems accurately remove rust areas on the surface of a steel material.[58] In chemical factories, the implementation of AI and robotics is shown to cause fewer errors during the packaging process than human labour.[59,60] In the mining sector, robots could assist in the 3D reconstruction process in geological exploration.[61]

AI AND ROBOTICS COULD DO SOME ASPECTS OF COMPUTING WORK

In our sample, nine papers discuss how AI and robotics can do some aspects of computing work. They can do repeatable computing tasks to decrease the burdens on human labour and they could do more precise work in computing than human labour in general.[62] For example, AI systems are used in the automatic extraction of data for input in and output from databases,[63] also, AI can automatically label computerised axial tomography (CAT) scans,[64] 2D and 3D X-ray microtomography and other health imaginal scans which normally requires manual review and label creation for each data item by human health experts.[65] Generally, AI application developments need many data points to be labelled and used as the training data to build an AI model. These tasks normally require a lot of human labour if the data labelling is done manually, but AI systems are now designed to do automatic data labelling and training and it helps to scale up computing project.[66,67]

Moreover, there are several AI applications in social media usage. AI can help in fact-checking and detecting fake news and rumours on social media before they spread widely online and cause individual and societal problems. Due to the enormous volume of data on social media, it is not efficient to only have human labour to conduct fake news detection.[68,69] Another example is that AI can be used in the automatic news or text classification with unstructured content from the web and social media; it is practically impossible for human labour to do text classification for all data on the Internet without help from AI.[70] Therefore, AI could reduce human burdens in certain computing activities.

AI AND ROBOTICS COULD DO WORK THAT HUMAN LABOUR DOES NOT WANT TO DO AND DEAL WITH THE LABOUR SHORTAGE

In our sample, 13 papers discuss how AI and robotics could do work that human labour does not want to do and at the same time deal with the labour shortage. AI and robotics simply add more labour-equivalent productivity into developed economies that are facing problems with aging populations and declining birthrates,[71] especially in Japan, where service robots have been developed for use in convenience stores to deal with the labour shortage. These robots perform tasks such as displaying and arranging products on shelves, disposing of expired food items, and interacting with customers.[72] Additionally, AI and robotics could help solve the human labour shortage problem in the areas far from cities that often have problems with finding staff.[73]

There were examples of how AI and robotics could help to deal with the shortage of human labour in several sectors. In the home care sector, there are cleaning robots for indoor spaces and service robots to grab objects and open a door, [74,75] and robots with hand gestures for elder care, as well as robots that are able to quickly recognise if elders suddenly fall.[76,77]

The manufacturing sector also faces similar problems regarding the labour shortage and AI and robotics could be helpful in, for example, ship hull maintenance and inspection services, where robots could do many operational tasks[78] and AI and robotics can assist in the trimming process of faucet manufacturing, without having human labour manually grasp and load materials into the trimming machine.[79]

In the agricultural sector, AI and robotics are used in the cultivation of apple and pear orchards and other farmlands for plant seeding, pruning, thinning, spraying, weeding, harvesting, mobile navigating and providing security to protect the land from intruders and wild animals. They also help to mitigate the problems related to the shortage of seasonal farm workers.[80,81,82] Moreover, AI and robotics can even match skilled workers with companies by using public data to build decision-making models.[83]

AI AND ROBOTICS COULD HELP TO REDUCE PRODUCTION AND MAINTENANCE COSTS

In our sample, 25 papers discuss how AI and robotics help to reduce the business production and maintenance costs, particularly in advanced industries with machinery workload.[84,85] In the farming industry, AI and robotics are used in automatic processes for detection and classification of apples and other fruits and crops for their ripeness and for harvesting and to prune trees by using mobile robots with near-ground sensors to measure the soil's electrical conductivity and soil moisture content, which optimises farming practices and increases crop yields, as well as solving the main problem of increasing human labour costs.[86,87,88] Similarly, in the evaluation of citrus plant condition[89] and the cane sugar crystallisation process, AI can perform automatic image classification during the processing of cane sugar.[90] Additionally, AI and robotics could be applied to a variety of agricultural activities including AI with wireless sensors in irrigation projects to monitor water and energy consumption in the farming fields to save on human labour costs, thereby maximising profits.[91]

In academia and medicine, AI can play a role in the process of citation screening for systematic literature reviews to lower the operational costs. This task typically relies on high-cost human labour.[92] Moreover, AI systems can also help to diagnose cardiovascular disease and disorders of the brain tissues and nervous systems by automatically interpreting magnetic resonance imaging (MRI) scans and electrocardiogram waveforms. Normally, a clinician must deal with hundreds of patients per day who need to be tested. In this case, AI systems will help to save healthcare operational costs and reduce the diagnostic workload.[93,94,95] Another aspect is how AI could auto-score sleep stages in humans for sleep studies, if this is done manually it will be costly, as it is labour intensive.[96]

In the construction sector, drones equipped with AI systems can reduce the cost of maintenance of solar panels by automatically detecting defective solar cells while at the same time minimising human labour costs.[97] Another example is when robotic arms at construction sites are tested to assemble a structure from predefined discrete building blocks and an AI simulation system can be used to train a human controller in the placing of building blocks.[98] Relying less on highly skilled and expensive human labour to do those jobs is helpful to firms. This also applies to the defect detection of power apparatus based on infrared photos taken and analysed by AI and robots.[99] Also, in the automobile industry, where AI and robotics are used in automobile repair shops to load and weld steel parts, the cost to buy them and implement them into work tasks are declining, so companies could increase profits by using AI and robotics and having less human labour related costs.[100,101] Moreover, autonomous robots can now construct bridges with minimised human labour, as a solution for businesses to deal with the high human labour costs in bridge construction, it is hoped robots will help to lower the cost of production by replacing human labour.[102]

In waste management, AI is developed to identify recyclable garbage in real-time based on AI automatic classification systems and image recognition technologies; this is also helping to reduce the huge costs of human labour in recycling tasks.[103,104]

In the manufacturing sector, AI and robotics are developed to perform in assembly lines to reduce the number and cost associated with human labour.[105] AI and robotics are experimented with for the purpose of painting ceramic plates, with the aim of reducing production costs and maximising productivity.[106] In another example, AI and robots are designed to undertake the gluing process for footwear, an area in which this industry normally uses a large volume of skilled and highly-compensated human labour.[107] For small businesses, AI chatbots with machine learning and natural language processing technologies, are being used more and more to provide customer support, to reduce the human labour costs.[108]

3.2 AI AND ROBOTICS CREATE NEGATIVE EFFECTS FOR HUMAN LABOUR

AI and robotics create negative effects for human labour mainly due to the automation of work, which directly affects the human labour market and can lead to the replacement of human labour in a wide range of occupations. Below are the reasons and examples as to how AI and robotics create negative effects for human labour.

AI AND ROBOTICS WILL TAKE OVER HUMAN LABOUR IN PART OR ENTIRELY AND WILL THEN CREATE AN UNEMPLOYMENT CRISIS

In our sample, 21 papers discuss how AI and robotics will take over from human labour, in part or entirely, and will subsequently create an unemployment crisis.[109,110,111,112,113,114] Workers are concerned about potential job displacement due to the automation of jobs by AI and robotics.[115] This concern is discussed in various occupational areas including in manufacturing,[116] service tasks[117] and in the software industry with regards to business process automation.[118] Also, in the mining industry where AI and robotics will require less human labour in the new mining operations, for instance mine trucks could be driven and controlled from a remote office.[119]

Other examples explore the use of AI and robotics in coconut farms for de-husking and loading coconuts and for monitoring the coconut plants' health by processing digital images of the plants, thereby replacing farm workers.[120] In date fruit farming, there will be less and less reliance on human labour expertise for grading and sorting of fruits when AI computer vision technology can perform those tasks.[121] In the service sector, including restaurants, the amount of human labour in the workforce is being reduced by robots, which are now performing as waiters to take orders and serve food to customers.[122]

Furthermore, the Organisation of Economic Co-operation and Development (OECD) indicated in its report that robots will displace human labour and will also decrease human labour's work compensation over time, particularly in the manufacturing sectors among OECD's member countries.[123] China is also worried about the same issue.[124]

Beyond the concerns that AI and robotics is likely to entirely take over much of human labour, thus creating an unemployment crisis, there is a worry that AI and robotics are also not good for social equality and could create more income inequality.[125,126,127] The effect could be that only management and skilled workers would be protected from the negative effects of AI and robotics as their work is unlikely to be replaced by AI and robots.[128] Therefore, it has been suggested that governments should introduce a 'robot tax' on companies, because AI and robots are believed to be increasingly taking away human labour work.[129,130]

AI AND ROBOTICS WILL NOT ONLY REPLACE MANUALLY REPETITIVE JOBS BUT ALSO COGNITIVE JOBS

In our sample, 15 papers discuss how AI and robotics cause problems in the labour market; they change and disrupt business models by not only replacing manually

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repetitive jobs from human labour but also cognitive and creative jobs, causing a feeling of vulnerability among human labour.[131,132,133] Repetitive human labour tasks will be the first to be replaced, but now AI and robotics can do the jobs that were more technically difficult in the past, including medical image processing of magnetic resonance imaging scans of the human body, rail inspection, monitoring crops in apple orchards, counting the number of trees, and going through warehouse aisles to pick up and store items. Those cognitive tasks were normally done by human labour but now AI and robots can do these jobs more accurately than any human labourer or technician.[134,135,136,137,138,139]

Even the IT sector cannot avoid this negative effect. AI and robotics systems have been replacing human IT service positions.[140] Another tangible example is that AI could be used to monitor and identify illegal FM radio broadcasting signals.[141] Soon, there might be less need for human labour when various AI systems become efficient at providing more IT services.

Moreover, several studies have shown that workers would prefer that their position were replaced by other human, not by AI or robots.[142] Overall, human labour feels fear that jobs may be replaced by AI and robotic automation.[143]

Conversely, other studies emphasise concerns that when robots replace human labour, most of the power and wealth could become even more concentrated in a small group of people and this will deepen the socio-economic gap and inequality.[144] Additionally, this points to another concern about human labour in low-income countries in the Global South, people who are doing a lot of the data sorting and sifting tasks manually for AI projects because AI systems rely on learning from a large volume of data, and this data needs to be cleaned in the countries that have low human labour costs. This could create another global income inequality problem.[145]

3.3 AI AND ROBOTICS CREATE NEUTRAL AND UNSURE EFFECTS FOR HUMAN LABOUR

In our sample, 28 papers discuss how AI and robotics create neutral and unsure effects for human labour. They could both substitute and complement human labour.[146,147,148] Some researchers believe that the total replacement of human labour by AI and robotics is not yet feasible and will not fully happen for a while, as the AI and robotics technologies are not quite there yet.[149,150] They are still currently considered a very new thing in many industries including retail and health care, where AI and robotics are still not yet being used in core operations but they hold a wide range of promising real-world applications.[151,152] In addition, consumers still prefer to have human labour to offer products and services to them, particularly when they are purchasing goods with high symbolic value and uniqueness.[153] Even with the rapid advancements of AI and robotics in construction, human labour is still needed in complex crafting processes.[154] Therefore, AI and robotics would not cause an unemployment crisis for human labour. It is very important for human labour to learn to collaborate or work alongside AI and robotics.[155,156,157,158,159,160,161]

The questions now are more about how to find the right balance between the use of AI and robotics and maintaining human labour employment.[162,163] To achieve the right balance, it is essential to position human labour at the forefront, thereby boosting their trust in AI and robotics and change perceptions of these so that they are seen as more of a source of self-improvement and positive employment change.[164,165] In some cases, AI and robotics will even allow human labour to dedicate themselves to doing more higher-level tasks, letting AI and robotics to do the groundwork.[166]

Another topic of discussion is about how AI is better at making predictions than human labour. Though true, humans are still better at making judgements.[167] The only way for AI and robotics to substitute human labour is if they can show that they can help to reduce business operational costs.

Some researchers go further by arguing that AI and robotics will negatively impact both those who consider themselves as ‘skilled and technical labour’ and the ‘unskilled’.[168] However, the AI and robotics impact on wage growth might be more significant for low-income occupations compared to middle and high-income technical jobs.[169]

Other neutral and unsure effects of AI and robotics on human labour include: (a) The belief that AI and robotics have both positive and negative effects (complementing or replacing human labour) depending on how they are implemented in a given workplace.[170] (b) Whether or not it is possible for both human labour and AI and robotics to equally share the tasks. And (c), whether AI and robotics will end up creating more productivity gains and make companies and societies wealthier, and this will be considered as some form of shared prosperity and inclusive economy between AI and robotics and human labour.[171]

Lastly, societies will continue to have a split view on AI and robotics effects on human labour.[172] We need to keep monitoring the workplace transformation and the increase of AI and robotics automated work environments and how they impact human labour.[173]

4. DISCUSSION AND SUGGESTIONS FOR FUTURE RESEARCH AND PRACTICAL RECOMMENDATIONS FOR LEGAL PROFESSIONALS AND POLICY MAKERS

Ultimately the findings of this review demonstrate that the positive effects of AI and robotics on human labour received more research attention than the negative

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effects. Compared to 103 studies focusing on positive effects, only 37 studies focused on the negative effects. To achieve more balance, we think that researchers should give more attention to the negative effects of AI and robotics on human labour. Interestingly, there are 28 studies that discussed the neutral and unsure effects of AI and robotics on human labour. It shows that some groups of researchers identify there are many unknowns with regards to emerging technologies like AI and robotics, especially regarding whether there will be full adoption in human societies and, particularly, in the workforce. We also still need more research in the area of neutral and unknown effects of AI and robotics.

Looking deeper at the themes of this review's findings, starting with the positive effects of AI and robotics on human labour, doing dangerous and tedious work and doing the work that human labour does not want to do, are both considered positive and, overall, sensible applications. Performing some aspects of computing work is becoming increasingly prevalent, especially when dealing with big data analysis, data organising, and data cleaning. AI and robotics help to reduce business production and maintenance costs as businesses are always looking for ways to save money. But how does the introduction of AI and robotics look from the perspective of employees who have to do their jobs while seeing the technology being introduced into their workplace? This could be an interesting study.

For the review's findings on the negative effects of AI and robotics, the main concern is about how they can replace human labour in various job categories. The studies that are mentioned discuss how human labour fear that their jobs will be replaced by AI and robotics. We think that this is an interesting research topic, to look at how we might reduce the fear felt by human labour, and to find ways to encourage human labour to see its adoption as an opportunity for them to improve their skills and leverage these technologies to their advantage. The research area on trust and trustworthiness of AI and robotic systems and products is important, because if human end users refuse to adopt the new technologies, even if they are made to the best standards, if they are not being used at all there is almost no point in creating the technology.

Finally, our findings show that there are some concerns about an unemployment crisis caused by AI and robotics. We think that there should be more serious studies with government policy makers and legal professionals to explore whether we should have laws that sets limits on how much businesses and employers could implement AI and robotics into their operations, especially if they could show that there are not a lot of productivity gains in having AI and robotics do the work compared to having human labour doing the same jobs.

Furthermore, what happens to people that were doing garbage collection (as an example) but had a meaning in their life by working and keeping busy. Now, even if they get paid, there is no meaning in their life, we can't expect everyone to become an AI expert or whatever the jobs of the future turn out to be. Another example is the job that a hi-tech executive has that is decision making, once a machine will make better decisions, what happens to she or he? How does meaning come to their life?

Additionally, we think there should be more AI and robotics research with under-served communities, particularly indigenous peoples, to understand how they perceive AI and robotics, and to delve into the intersections between indigenous ways of knowing and being and the utilisation of AI and robotics in a workforce; their ways of life, cultures, languages, and relationships with the land. These findings may not be published in academic databases but rather in conversations and interviews with indigenous peoples living in these communities, including urban centres. Does AI and robotics align with indigenous ways of knowing, or does it work against it? Or is there a middle ground?

These suggested tasks need complex legal and public policy thinking and involvement by people from business, labour unions, governments, academia, and from consumers. We believe such legal and policy studies are important and should be explored.

5. CONCLUSION AND LIMITATION

The future is not set in stone. How AI and robotics will affect society is up to us to decide. We can do this by making policies that reduce the negative effects on society and increase the positive ones. For society to make informed decisions about the effect of AI and robotics, getting a good overview of the findings reported in the literature is important. Our hope is that this literature review will help in the effort of making policies that ensure that society as a whole gains from the introduction of AI and robotics.

In this systematic literature review, we identify the positive, negative, and neutral and unsure effects of AI and robotics on human labour in the existing literature. We also discus key gaps in the literature and give some suggestions for future research and practical recommendations for legal professionals and policy makers. This review has a limitation, as it did not include non-scientific literature such as policy reports, working papers, and government and non-government organisation documents.

Endnotes

[1] Min Xu, Jeanne M. David, and Suk Hi Kim, 'The Fourth Industrial Revolution: Opportunities and Challenges' *International Journal of Financial Research* 9, no. 2 (2018) 90–95.

[2] We started conducting this review in February 2022, before the public launch of the ChatGPT generative AI tool. As a result, no ChatGPT-related studies were included in this review. However, we are currently conducting another systematic review on ChatGPT's ethical issues, including its effects on human labour.

[3] Co-author Channarong Intahchomphoo conducted databases search, reviewed studies, and created the codebook for the themes for included studies. Co-authors Jason Millar, Odd Erik Gundersen, Christian Tschirhart, Kris Meawasige, and Hojjat Salemi commented on the overall research methodology, data analysis and discussion.

[4] For transparency of this review, the metadata of included and excluded studies from all databases search can be found at https://github.com/ChannarongIntahchomphoo/Effects-of-AI-and-robotics-on-human-labour

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