Untapped Potential?: Using Technology to Reduce Women's Domestic Labour Burdens

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Contents

Abbreviations

CRI	Child-Robot Interaction
HILDA	Household, Income and Labour Dynamics Survey
ICT	Information Communication Technology
IoT	Internet of Things
IP	Intellectual Property
MOOC	Massive Open Online Courses
OECD	Organisation for Economic Co-operation and Development
RiSH	Robot-Integrated Smart Home
STEM	Science, Technology, Engineering and Mathematics

Executive Summary

This report explored the potential of technology to reduce women's labour in the home. Though women have made great inroads into paid employment in the past century, many women are expected to take on both paid work and a disproportionate share of household duties. This 'second shift' of housework and childcare can negatively affect women's physical and mental wellbeing, and limit career prospects. With the onset of the COVID-19 pandemic, which has exacerbated gendered divisions of labour both outside and within the home and accelerated acceptance of technology, now is a crucial time to examine what role, if any, technology can play in ameliorating the unequal distribution of domestic work.

This report discussed six key barriers which may dissuade women from adopting emerging technologies in their homes:

- The limitations of current technology to effectively mimic human behaviours and take over carers' duties;
- The failures of technology in the 20th century to significantly reduce the time women spent on domestic labour, and digital labour in the present possibly mitigating any time-saving effects of modern technology;
- Digital housekeeping primarily being carried out by men, thus reducing women's opportunities to choose, understand, and utilise the technology in their homes;
- The digital gender divide, beginning in childhood and leading to the underrepresentation of women in STEM, ultimately resulting in technology which reflects gender biases and largely fails to account for women in its designs;
- Security of personal data and the safety risks associated with smart technology in the home; and
- Acceptance (or lack thereof) of emerging technologies, and mothers potentially refusing to cede housework and childcare responsibilities to others.

Finally, this report examined possible solutions and opportunities, including two case studies:

- Gerontechnology is a field of technology which aims to ensure the comfort and health of elderly residents living in smart homes. The rich literature in this field offers many possibilities for creating holistic and integrated smart home systems, which have the potential to reduce labour in the home; and
- Educational robotics draws from a growing body of research on Child-Robot Interaction (CRI), and contains useful insights for the future development of domestic robots, which currently have limited childcare capabilities; and
- Closing the digital gender divide and encouraging more women to enter STEM is vital for the development of technology that empowers women; Australia has made some progress on this front, but change has been slow.

Introduction

The past century has witnessed a dramatic transformation of gender norms around work and care. Increasingly, households have moved towards a dual-earner model, and in some homes, men are doing just as much- if not more- domestic labour compared to their female counterparts.[1] Yet, these trends fall significantly short of a large-scale, societal transformation of how labour is shared between men and women, as shown by recent results from HILDA, Australia's nationally representative household survey, which indicate that women on average spend 13 hours more each week on unpaid work- including housework and care- than men.[2] Instead, expectations of women have shifted from housewife to 'supermum', a mother who deftly combines paid employment with domestic work; placing increasing pressure on women's time and labour.[3] Thus, there is still much work to be done in addressing women's 'second shift'; and modern technology may offer some avenues through which this can be achieved. In the 19th and 20th centuries, innovations such fridges and microwaves purportedly revolutionised women's domestic labour.[4] However, the question of whether the current wave of new technologies; the smart kitchen, or social robots, will have similar effects has yet to be answered.

Moreover, the COVID-19 pandemic has accelerated acceptance and use of a wide variety of technologies, due to practices such as working from home and the need for socially-distant spaces and interactions.[5] The pandemic has also disproportionately affected women's workforce participation and exacerbated existing gender divides in household labour, posing a new challenge to efforts toward greater gender equality.[6] During lockdown, women performed an hour more housework compared to pre-pandemic while men performed 40 minutes more, with the gender gap in housework increasing from 22% to 24%.[7] Thus, the pandemic has highlighted both the urgent need to address the 'second shift' many women are expected to participate in, and the potential for technology to play a part in this process.

The research question that this report explores is: What role can emerging technologies play in reducing the burden of the second shift for women? Unfortunately, research on this specific topic is thin. There exists an entire field of technology for supporting the elderly and their carers, yet a similarly robust field does not exist for children and their carers.[8] Many new technologies claim to reduce labour and increase leisure, but their impact on women's labour in the home has not been rigorously studied. The gender gap in care work and housework has been extensively discussed, but technology is rarely raised as a potential solution. Hence, given the paucity of information on this research topic, this report takes an exploratory rather than prescriptive approach, favouring a broad examination of potential opportunities and barriers over a definitive list of policy recommendations.

Furthermore, this report acknowledges that the unequal distribution of housework and care work is a complex, multidimensional issue which requires responses across a number of spheres; in policy- including areas such as childcare provision and paid parental leave- in the academia, in industry, and through shifting societal perceptions around care and gender roles. However, these topics are beyond the scope of this report; this report's main focus is on new technologies and the opportunities which they provide. Furthermore, this report is aimed at a general audience assumed to have a basic level of technological awareness and proficiency, and therefore does not delve too deeply into technical languages and concepts. However, this report acknowledges that future research would benefit from a more holistic approach that examines both the social and technical aspects of this topic.

Section 1 of this report provides the context of this issue, beginning with a historical perspective on women's labour in the home. It explains the concept of the 'second shift', and investigates the differences between the housework and care work that women and men typically perform, and the impact of this work on women's health and work prospects. Finally, it examines the impact of the COVID-19 pandemic on the gendered division of labour.

Section 2 is a broad examination of the gaps in the literature, barriers to using new technology, and existing limitations of these technologies. This section considers the digital gender divide, the capacity of technology to effectively replace human labour, issues of surveillance and privacy, and whether or not women even want such technologies in their homes.

Section 3 investigates opportunities for the future of domestic labour-saving technologies through two case studies. These case studies represent two fields of technology which have the potential to be adapted or expanded into the home and made available for a wider consumer base: smart homes designed for the elderly, and robots in the education sector. This section also discusses efforts to close the digital gender divide and promote women's participation in designing the technologies that will impact their lives.

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[1] Jieon Lee, Daeho Lee, and Jae-gil Lee, "Can Robots Help Working Parents with Childcare? Optimizing Childcare Functions for Different Parenting Characteristics," *International Journal of Social Robotics*, (2021): 2, doi: 10.1007/s12369-021-00784-8.

[2] "HILDA reveals no real change in gender roles," *The University of Melbourne: Newsroom*, July 31, 2018, https://about.unimelb.edu.au/newsroom/news/2018/july/hilda-reveals-no-real-change-in-gender-roles; Julie MacLeavy, "Care Work, Gender Inequality and Technological Advancement in the Age of COVID-19," *Gender, Work & Organization* 28, no. 1 (2021): 141, doi: 10.1111/gwao.12534.

[3] Lisa Selin Davis, "It's 2021. Why Is 'Supermom' Still Around?" *The New York Times*, June 4, 2021, https://www.nytimes.com/2021/06/04/us/supermom-work-family-kids.html.

[4] Ronald R. Kline, "Ideology and Social Surveys: Reinterpreting the Effects of 'Laborsaving' Technology on American Farm Women," *Technology and Culture* 38, no. 2 (April 1997): 356, doi: 10.2307/3107126

[5] *ibid,* 148.

[6] Lyn Craig and Brendan Churchill, "Working and Caring at Home: Gender Differences in the Effects of Covid-19 on Paid and Unpaid Labor in Australia," *Feminist Economics* 27, no. 1–2 (April 3, 2021): 313, doi 10.1080/13545701.2020.1831039.

[7] *ibid,* 316.

[8] Masahiro Shiomi and Norihiro Hagita, "Social Acceptance toward a Childcare Support Robot System: Web-Based Cultural Differences Investigation and a Field Study in Japan," *Advanced Robotics* 31, no. 14 (July 15, 2017): 727, doi: 10.1080/01691864.2017.1345322.

Section 1: Context

A Brief History

Though aided by technology, a woman in the modern age is typically expected to perform domestic labour equivalent to the work undertaken by several people prior to the Industrial Revolution. Though only middle- and upper-class families had full-time domestic servants in the preindustrial era, many households employed domestic servants on a seasonal or part-time basis.[9] Hence, the work required to maintain the household was often carried out by multiple people: servants, hired hands, and children. Women were typically the overseers of this work, and may have personally performed some of the more careful or skilled labour tasks, such as producing textiles or medicines.[10]

However, the Industrial Revolution brought with it an increase in the costs of labour, and more opportunities for working outside the household. These factors, combined with the introduction of new technologies such as the washing machine and vacuum cleaner, reduced the need for hired help and shifted the norm of outsourcing labour to commercial services into women carrying out the majority of the unpaid domestic work.[11] Despite the assistance of technological innovations, women now are required to do just as much- if not more- work in the home compared to their preindustrial counterparts, as a single person shoulders the burden of work previously carried out by multiple people.

A Stalled Revolution

Cultural change around gender roles in the past century had led some analysts to predict that men and women would soon equally share household duties. This prediction, unfortunately, has not borne fruit. Rather, the reality of what some scholars have called a "stalled revolution" has emerged; while women have achieved many successes in paid work and labour market participation, men have not made a parallel effort to take on a more equitable share of work in the domestic sphere.[12]

Instead, women's increased participation in paid work has resulted in a care deficit in a number of countries; a gap which is somewhat filled with outsourcing this labour to the market, but is more often filled by women combining their paid work outside the home with unpaid labour at home.[13] Thus, women still assume the majority of household duties regardless of the hours they also spend in paid work; especially working women who cannot afford to outsource this labour.[14]

The Second Shift

The "second shift" is a concept popularised by sociologist Arlie Hochschild in the 1980s to explain the growing expectation that women play a dual role as both worker and carer.[15] During the day, women are engaged in paid employment- the 'first shift'- but even when their work day formally ends, their labour does not. After coming home, women are expected to clock into their 'second shift'; housework and caring for children, essentially working a "double day".[16] Hochschild's research found that, if the hours of women's 'first' and 'second' shifts were totalled, on average, women worked 15 hours longer each week, or a month more each year, compared to men.[17] The specifics of this claim have since been challenged, with other academics arguing that 15 hours is an overestimation, but the contention that women work more total hours when factoring in the 'second shift' is generally supported.[18] One example is sociologist Lyn Craig's work, who found that in Australia, if counting hours that women multitasked during housework and childcare, women worked around 20-25% more than their male counterparts.[19]

[9]Jathan Sadowski, Yolande Strengers, and Jenny Kennedy, "More Work for Big Mother: Revaluing Care and Control in Smart Homes," *Environment and Planning A: Economy and Space*, (2021): 2, doi: 10.1177/0308518X211022366.

[10]*ibid.*.

[11]*ibid.*.

[12]Lyn Craig, "Is There Really a Second Shift, and If so, Who Does It? A Time-Diary Investigation," *Feminist Review* 86, no. 1 (July 2007): 152, doi: 10.1057/palgrave.fr.9400339.

[13]MacLeavy, "Care Work," 141-2.

[14]Alicia Dugan and Janet Barnes-Farrell, "Working Mothers' Second Shift, Personal Resources, and Self-Care," *Community, Work & Family* 23, no. 1 (January 2020): 64, doi: 10.1080/13668803.2018.1449732.

[15]Arlie Russell Hochschild, *The second shift: working parents and the revolution at home* (New York: Viking, 1989).

[16]Melissa Milkie, Sara Raley, and Suzanne Bianchi, "Taking on the Second Shift: Time Allocations and Time Pressures of U.S. Parents with Preschoolers," *Social Forces* 88, no. 2 (2009): 487.

[17]*ibid.*, 488.

[18]*Ibid.*, 509.

[19]Ibid, 489.

	Male-breadwinner		Approximately-even		Female-breadwinner	
	Males	Females	Males	Females	Males	Females
2015–2017						
Couples without dependent children						
Total time	63.4	51.4	57.2	60.9	49.2	59.6
Housework	14.9	22.1	12.3	16.3	16.2	17.6
Couples with dependent children						
Total time	76.8	76.5	75.9	80.6	68.1	80.9
Housework	15.3	29.4	16.1	23.1	19.1	24.1
Child care	10.9	25.7	11.1	18.2	11.2	19.3

Figure 1. Mean working time of males and females in couples, by earnings arrangement (hours per week). Roger Wilkins, Inga Laß, Peter Butterworth and Esperanza Vera-Toscano, *The Household, Income and Labour Dynamics in Australia Survey: Selected Findings from Waves 1 to 17* (Melbourne: Melbourne Institute: Applied Economic & Social Research, 2019), 98, https://melbourneinstitute.unimelb.edu.au/__data/assets/pdf_file/0010/3398464/HILDA-Statistical-Report2019.pdf.

Furthermore, the concept of the 'second shift' not only describes the existence of women's dual duties; it also explores the nature of this work. According to Hochschild, women's labour in the household is characterised by its drudgery and repetitiveness, such as cleaning, laundry, and cooking.[20] In contrast, men tend to do more occasional, discretionary chores, such as home repairs or yard work.[21] This divide also applies to childcare, wherein mothers' care work is generally more routine and 'unpleasant', such as bathing or feeding children, and more likely to be carried out alone.[22] On the other hand, father-child interactions are more often educational or recreational, and significantly more likely to be performed with or in the presence of the mother. [23]

Finally, in addition to the more easily measurable duties of housework and childcare, less visible tasks such as emotional labour and household management are also more frequently carried out by women. Women are more likely to be responsible for diffusing conflicts, comforting and encouraging others, and facilitating smooth interactions between household members.[24] Household management, sometimes known as the 'mental load', typically involves women being in charge of coordinating and keeping track of tasks ranging from making medical appointments to planning family holidays, while men are more commonly cast in the role of their assistant, if they are involved at all.[25]

The impact of the second shift

This uneven distribution of labour has a significant effect on women's physical and mental health, and job prospects. Having a greater share of domestic labour responsibilities contributes to women being more likely to work casually or part-time in comparison to men.[26] In turn, when children are born, women- who tend to earn less- are often nominated as the partner who gives up all or part of their paid employment to care for the children, as it makes more 'economic sense'.[27] Furthermore, mothers' childcare responsibilities tend to pose more of an obstacle to full-time employment compared to fathers', given that mothers are more likely to take on routine, inflexible duties such as picking children up from school and shuttling them to after-school activities, whereas fathers may be able to fit more flexible activities such as playtime with children around their own full-time work schedules.[28] This lack of flexibility in childcare duties can also constrain mothers' career advancement, as their more rigid schedules may not allow for opportunities such as networking with colleagues or travelling to attend conferences.[29]

The second shift also takes a physical and psychological toll on women. Because of their many responsibilities, women and especially working mothers report higher stress levels and feelings of being under pressure, and lower life satisfaction compared to working fathers.[30] Women also have less time for leisure, and that leisure itself may not always be completely personal 'free' time, as women can still feel obliged to perform their caregiving duties if in the presence of their family members, such as supervising their children while watching television. Furthermore, while mothers tend to reduce their hours of housework as paid work hours increase, the same is not true for childcare; even while working, mothers often cut into their own self-care, leisure and even sleep hours in order to care for their children.[31]

[20]Dugan and Barnes-Farrell, "Working Mothers," 64.

[21]*ibid*.

[22]Lyn Craig and Killian Mullan, "How Mothers and Fathers Share Childcare: A Cross-National Time-Use Comparison," *American Sociological Review* 76, no. 6 (December 1, 2011): 838, doi: 10.2307/23102557.

[23]*ibid*.

[24]*ibid*.

[25]*ibid*.

[26]MacLeavy, "Care Work," 142.

[27]*ibid*.

[28]Craig and Mullan, "How Mothers and Fathers Share Childcare," 838.

[29]*ibid*.

[30]Dugan and Barnes-Farrell, "Working Mothers," 63.

[31]Craig, "Is There Really a Second Shift," 153.

The impact of COVID-19

The impact of the COVID-19 pandemic on the household division of labour has been unevenly distributed. Lockdown closed workplaces, schools, and childcare centres, resulting in households struggling to adjust to their new work and care situations. Due to female-dominated industries such as hospitality being some of the hardest-hit by the pandemic, women were more likely to lose their jobs, and housework and care work obligations were more likely to default to women.[32] In fact, although both men and women increased their daily hours of housework and care work in response to this shift, this has not significantly narrowed the gender gap.[33]

During lockdown, the relative gender gap in active childcare narrowed, but the absolute time difference increased, with women averaging an hour and twenty minutes more in active childcare compared to pre-COVID hours while men averaged just over an hour more.[34] Parents also increased their hours in supervisory care, but the stark gender difference persisted, with mothers performing an average of 4.24 hours of supervisory care versus fathers' 2.85 hours.[35] Compared to men working from home, who did not work fewer paid work hours or perform more multitasking, women who worked from home did less paid work, more unpaid domestic labour and care, and more multitasking by supervising children while working.[36] These trends indicate that for men the boundaries between paid work and household work were clearly delineated, but for women, these two spheres increasingly blurred into each other. Unfortunately, this shows that the pandemic has the potential to erode women's advancements into the labour market in past decades and reinforce more traditional gender roles and practices. Hence, given the widespread impact of the pandemic and its already-visible effects on the gendered division of labour, it is imperative that potential responses to these trends are examined, and the question of what role, if any, technology can play is thoroughly considered.

[32]Yue Qian and Sylvia Fuller, "COVID-19 and the Gender Employment Gap among Parents of Young Children," *Canadian Public Policy* 46, no. 2 (August 1, 2020): 90, doi: 10.3138/cpp.2020-077.

[33]Craig and Churchill, "Working and Caring at Home," 316.

[34]*ibid*.

[35]*ibid*, 317.

[36]*ibid*., 313.

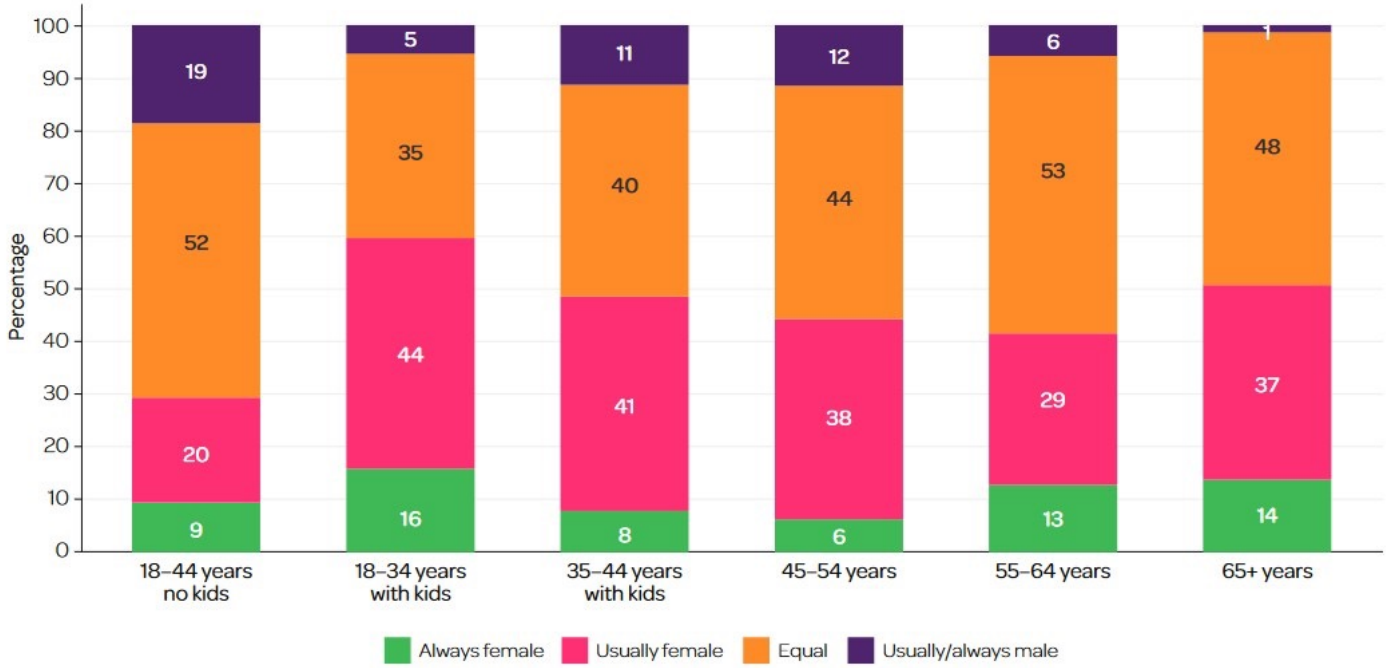

Figure 2. Sharing of household tasks by age of respondent, and presence of children under 18 years, all couples. Australian Institute of Family Studies, *Families in Australia Survey: Towards COVID Normal* (Commonwealth of Australia, 2021), 10, https://aifs.gov.au/sites/default/files/publication-documents/2109_5_fias_sharing_housework_in_couple_families.pdf.

Section 2: Gaps, barriers, and limitations

The topics below are not an exhaustive list, but a collection of the most commonly identified concerns regarding this report's research question. Before emerging technologies can be put forth as a suitable and effective tool for reducing women's household labour, these complex, interlinked concerns must first be recognised and addressed.

Technology and its capabilities

The 'human touch'

When considering robots, there are serious doubts regarding their ability to effectively carry out a human caretaker's typical duties. Unfortunately, rigorous research on robots' abilities to care for children and promote their social and emotional development in the home setting does not yet exist. However, the literature on elderly and disability care robots may provide some insights.

Research into robots utilised by elderly care facilities and disability service organisations reveal that most staff are wary of utilising robots in more personal or intimate situations with their patients.[37] A number of staff expressed their belief that care robots should be used to support carers by taking over the more tedious and physically challenging duties- such as lifting patients- rather than entirely replacing carers in their duties.[38] Some researchers also argue that robots cannot form genuine bonds with patients due to their inability to experience emotions, and thus patients can only have their emotional needs satisfied through deception; the deception that a machine can truly care about them and be concerned for their comfort and safety.[39] These academics warn that such robots risk turning caregiving into a detached, objectified and depersonalised mimicry of a deeply subjective and intimate responsibility.[40] Hence, the inability of care robots to recreate the 'human touch' and the emotional connection it entails may lead to sensory deprivation and feelings of isolation and alienation in patients.[41]

Other technological limitations

Although technical details are not the focus of this report, it is nevertheless important to note where new technology has largely failed to meet expectations. For example, the smart home market has experienced slower growth than predicted and is currently in a state of stagnation due to a plethora of issues: high prices, "glitchy" devices, long replacement periods, overly complex technologies, and lack of understanding of consumer's desires or needs.[42] A particularly common complaint is the fragmentation of technologies; many currently available products are standalone and only carry out one or a handful of tasks, creating a range of devices which are incompatible with products from other manufacturers and resulting in a smart home system that is neither cost-effective nor energy-efficient.[43]

In terms of robots, several major technological limitations have also been identified. Currently, educational robots are most effective when teaching children simple and discrete tasks; the more complex the lesson or goal, the higher the likelihood of breakdowns in interactions with children.[44] Many robot tutors also only display a limited ability to operate autonomously; most still require covert or even overt intervention and remote control by humans.[45] This has significant implications for the research question this report is attempting to answer; if childcare robots still require constant monitoring by parents, then their effect on reducing the time mothers spend on childcare duties may be negligible.

Currently, the design of childcare robots is not sophisticated enough for the robot to understand and respond to a child's cues in a nuanced and sensitive manner. Though robots are continually being improved, in the near future it is unlikely that social robots will have the ability to satisfactorily model appropriate social behaviours and interactions to children or nurture their emotional intelligence. Additionally, current robots are not linguistically competent enough to engage in conversations beyond a superficial level. Although robots may be able to instantaneously search for and respond to a child's general knowledge or trivia questions, more complex cultural and philosophical discussions are an entirely different matter.[46] Indeed, robot manufacturers appear to be cognizant of the limited capacities of modern technology, with some reminding buyers that social robots are not intended to act as a replacement for parents or friends, or even as a standalone babysitter.[47]

[37] Gregor Wolbring and Sophya Yumakulov, "Social Robots: Views of Staff of a Disability Service Organization," *International Journal of Social Robotics* 6, no. 3 (August 2014): 465, doi: 10.1007/s12369-014-0229-z.

[38] *ibid.*

[39] Jennifer A. Parks, "Lifting the Burden of Women's Care Work: Should Robots Replace the 'Human Touch'?," *Hypatia* 25, no. 1 (2010): 107, doi: 10.1111/j.1527-2001.2009.01086.x.

[40] MacLeavy, "Care Work," 142.

[41] *ibid.*, 148.

[42] Yolande Strengers et al., "Protection, Productivity and Pleasure in the Smart Home: Emerging Expectations and Gendered Insights from Australian Early Adopters," (Paper presented at the CHI Conference on Human Factors in Computing Systems, Glasgow, Scotland, 2019), 1. doi: 10.1145/3290605.3300875.

[43] Sumit Majumder et al., "Smart Homes for Elderly Healthcare--Recent Advances and Research Challenges," *Sensors* 17, no. 11 (November 2017): 10, doi: 10.3390/s17112496.

[44] Sophia Serholt, "Breakdowns in Children's Interactions with a Robotic Tutor: A Longitudinal Study," *Computers in Human Behavior*, no. 81 (2018): 263, doi: 10.1016/j.chb.2017.12.030.

[45] Amanda J. C. Sharkey, "Should We Welcome Robot Teachers?," *Ethics and Information Technology* 18, no. 4 (December 2016): 286, doi: 10.1007/s10676-016-9387-z.

[46] Amanda Sharkey and Noel Sharkey, "Children, the Elderly, and Interactive Robots: Anthropomorphism and Deception in Robot Care and Companionship," *IEEE Robotics & Automation Magazine* 18, no. 1 (2011): 37, doi: 10.1109/MRA.2010.940150.

[47] Dean Takahashi, "Meet iPal: a robot companion for kids and the elderly," *VentureBeat*, January 4, 2017, 6:00 a.m., https://venturebeat.com/2017/01/04/avatarmind-unveils-ipal-companion-robot-for-kids-and-elderly/.

More work for mother?

An industrial revolution in the home

More Work for Mother is the title of historian Ruth Schwartz-Cowan's influential book on the changes (or lack thereof) in women's housework time after the introduction of labour-saving technologies. Since the 1970s, Schwartz-Cowan and various other academics have found that the time women spend on housework has not significantly decreased despite technological innovations in the 20th century, and the time that mothers dedicate to childcare has in fact increased.[48]

Between the 1920s and 1970s, many Western countries experienced an "industrial revolution in the home" as households acquired indoor plumbing and electricity.[49] Homes also became easier to maintain with the burgeoning popularity of wall-to-wall carpeting and laminate and vinyl floors.[50] Over this period, many labour-saving appliances and innovations became ubiquitous in middle class households, including electric vacuum cleaners, gas and electric refrigerators and freezers, processed foods, electric and automatic washing machines, and wash-and-wear fabrics.[51] At the time, these changes were widely heralded as a modernization of the home that would reduce women's labour, increase leisure, and eliminate drudgery.[52]

Similar levels of housework

Scholars have attributed the relatively unchanging amount of time that women spend on domestic chores to changing sociocultural norms in Western countries, especially in middle class families. Scientific advancements in the understanding of diseases and bacteria led to rising standards of hygiene in the home.[53] Whereas previously the wellbeing of the household may have been perceived as controlled by god or 'fate', the homemaker now became responsible for protecting the family's health by maintaining a requisite level of cleanliness in the home.[54] The discovery of vitamins and minerals in this period also created expectations that women regularly use fresh ingredients to cook meals from scratch to ensure a healthy diet for family members.[55] Hence, a newfound emphasis on the behavioural causes of good or ill health raised the standards for housework, offsetting the effect of the proliferation of modern convenient appliances. Lastly, as mentioned in the previous section, the industrial revolution also led to a decline in the number of domestic servants that a household typically employed, shifting the activities which were previously brought in the market- and performed by several people- into the home, thereby increasing women's domestic workload.[56]

Higher levels of care work

In terms of childcare, research showing that women spend an increased amount of time on childcare compared to their counterparts several generations ago also point to changing sociocultural norms as the cause. Reforms in the late 19th and early 20th centuries were centered on the changing belief that children and childhood were worth protecting, resulting in limitations and eventually bans on children working in factories and the provision of education for children.[57] Middle class families in the 20th century also increasingly invested time and effort into their children's social and cultural capital to improve their chances of upward social mobility and increased future earnings.[58] This is especially pronounced in the United States, where competition for scarce slots at prestigious colleges has become increasingly intense.[59] Parents, and mothers in particular, are thus more likely to enrol their children in a range of extracurricular activities, spend time shuttling them to their activity locations, and remain with them in order to ferry them home later.[60]

Population trends may have also contributed to this phenomenon, as parents having less children may have promoted a 'quality over quantity' approach to parenting and an overprotectiveness over the few children that families have.[61] The erosion of community bonds in neighbourhoods and a heightened sensitivity to crime and children's safety have also resulted in a reduction in unsupervised playtime with neighbourhood children more commonly seen in previous generations.[62] Children nowadays are more likely to be monitored by parents in scheduled play dates, thus increasing the total amount of time women currently spend on childcare-related tasks compared to women several decades ago, especially in the evenings and weekends.[63]

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[48]D.D. Furszyfer Del Rio, B.K. Sovacool, and M. Martiskainen, "Controllable, Frightening, or Fun? Exploring the Gendered Dynamics of Smart Home Technology Preferences in the United Kingdom," *Energy Research & Social Science* 77 (July 2021): 8, doi: 10.1016/j.erss.2021.102105.

[49]Michael Bittman, James Mahmud Rice, and Judy Wajcman, "Appliances and Their Impact: The Ownership of Domestic Technology and Time Spent on Household Work," *British Journal of Sociology* 55, no. 3 (September 2004): 402, doi: 10.1111/j.1468-4446.2004.00026.x.

[49]Jonathan Gershuny and Teresa Atttracta Harms, "Housework Now Takes Much Less Time: 85 Years of US Rural Women's Time Use," *Social Forces* 95, no. 2 (December 1, 2016): 512.

[50]*ibid.*

[51]Kline, "Ideology and Social Surveys," 356.

[52]Gershuny and Harms, "Housework Now Takes Much Less Time," 504.

[53]Joel Mokyr, "Why 'More Work for Mother?' Knowledge and Household Behavior, 1870-1945," *The Journal of Economic History* 60, no. 1 (2000): 17, https://www.jstor.org/stable/2566795.

[54]*ibid,* 19.

[55]*ibid,* 3.

[56]*ibid,* 9.

[57]Gershuny and Harms, "Housework Now Takes Much Less Time," 512.

[58]Garey Ramey and Valerie Ramey, "The Rug Rat Race," *Brookings Papers on Economic Activity,* (2010): 131.

[59]Liana C. Sayer, Suzanne M. Bianchi, and John P. Robinson, "Are Parents Investing Less in Children? Trends in Mothers' and Fathers' Time with Children," *American Journal of Sociology* 110, no. 1 (July 2004): 9, doi: 10.1086/386270.

[60]Gershuny and Harms, "Housework Now Takes Much Less Time," 512.

[61]Sayer, Bianchi, and Robinson, "Are Parents Investing Less in Children?" 9.

[62]*ibid.*

Implications for modern technology

These findings suggest that even when dramatic technological changes occur in the home, their effectiveness may be limited by countervailing external forces, such as a shift in sociocultural norms or population trends. In fact, some evidence points to emerging technologies instead becoming a new source of labour or housework, once again creating 'more work for mother'. People who acquire new technologies may be required to devote a substantial portion of their time to "digital labour" or "digital housekeeping", including researching products, integrating, maintaining, upgrading and monitoring technology, troubleshooting problems, and educating other household members on the proper use of devices.[64] Some technology may also require manual labour to function correctly, such as moving objects around to ensure that the robot vacuum cleaner can access hard-to-reach areas.[65] Indeed, one study of 18 Australian households found that while many householders reported that their lives had become simpler and easier since adopting smart home technologies, they also doubted that these technologies were saving them time or reducing their labour.[66] Of course, one study is not enough to form compelling conclusions, and literature on this topic is still quite scarce. Furthermore, the subject of whether the current wave of new technologies will have a similarly limited effect on reducing women's domestic work- or even creating new demands on women's time and effort- as with the 20th century's innovations, remains largely unstudied.

Gendered digital housekeeping

Digital housekeeping refers to the work required to maintain the smart home and the technologies contained within, and ensure that it runs smoothly.[67] Oftentimes, the duties associated with digital housekeeping are not shared equally in the household but fall to one "technical guru" or "technical czar" with the required technological expertise.[68] This technical guru is responsible for installing technologies in the home, maintaining and fixing them, and introducing them to other members of the household, and is more commonly male.[69] Studies have shown that compared to women, men are more likely to own smart home devices, are more familiar with such devices, hold more positive attitudes toward technology, and more commonly consider themselves the technological expert in the home, while women are more likely to express disinterest in technology-related management or decision-making.[70]

What are the implications of these gendered results when considering women's 'second shift'? On one hand, delegating a portion of the housework to be carried out by technology- which is in turn overseen by a male household member- could result in a reduction of women's domestic workload; women's housework is transformed into men's digital labour. On the other hand, some anecdotal evidence suggests that digital housekeeping may cut into the time men typically spend carrying out other domestic tasks, which then need to be compensated by other household members.[71] As such, whether the introduction of modern technologies would actually meaningfully impact the gendered division of labour should be carefully considered. Moreover, if women are excluded from the process of selecting and managing the technologies in their homes- either deliberately by male household members or through their own lack of interest or expertise- their ability to leverage said technology to accomplish their own goals and promote their own comfort and ease may be limited.

The digital gender divide

As a highly male-dominated industry, much of the technology currently on the market and in development reflects the unconscious biases of its creators, and risks perpetuating and exacerbating gender inequality rather than ameliorating it. Examples of these biases are voice assistants such as Alexa and Siri. These overwhelmingly female voice assistants, who are coded to react to hostile or sexually explicit interactions with flirtatious or at most neutral responses, may reinforce cultural stereotypes of women as docile, servile, and tolerant of poor treatment.[72] Importantly, the digital gender divide means that women's voices and concerns are not being incorporated into technology, which in turn limits these technologies' capacities to empower women and effectively respond to their needs.

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[64] Yolande Strengers and Larissa Nicholls, "Aesthetic Pleasures and Gendered Tech-Work in the 21st-Century Smart Home," *Media International Australia* 166, no. 1 (February 2018): 76, doi: 10.1177/1329878X17737661.

[65] *ibid,* 75.

[66] *ibid.*

[67] Sadowski, Strengers, and Kennedy, "More Work for Big Mother," 10.

[68] Furszyfer Del Rio, Sovacool, and Martiskainen, "Controllable, Frightening, or Fun?" 6.

[69] Sadowski, Strengers, and Kennedy, "More Work for Big Mother," 10.

[70] Amber Marshall, "Women's Pathways to Digital Inclusion Through Digital Labour in Rural Farming Households," *Australian Feminist Studies*, (August 27, 2021): 6, doi: 10.1080/08164649.2021.1969519; Furszyfer Del Rio, Sovacool, and Martiskainen, "Controllable, Frightening, or Fun?" 2.

[71] Jenny Kennedy et al., *Digital Domesticity: Media, Materiality, and Home Life* (New York: Oxford University Press, 2020), 157-8.

[72] EQUALS, *I'd Blush If I Could: Closing Gender Divides in Digital Skills Through Education* (UNESCO, 2019), 105, https://unesdoc.unesco.org/ark:/48223/pf0000367416.page=7.

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[72] EQUALS, *I'd Blush If I Could: Closing Gender Divides in Digital Skills Through Education* (UNESCO, 2019), 105, https://unesdoc.unesco.org/ark:/48223/pf0000367416.page=7.

The digital gender divide begins at a young age between girls and boys, and widens exponentially as girls progress through secondary and tertiary education and move into the workforce. Despite actual digital competence levels, and mathematics and science skills between girls and boys being the same or even slightly higher among girls in primary and lower secondary school, girls report lower levels of self-efficacy.[73] In secondary school, girls tend to lose interest in STEM subjects earlier than boys, and opt out of STEM courses at higher rates.[74] In terms of aspirations, in OECD countries only 5% of girls reported wanting a career in computing and engineering compared to 18% of boys, and ICT-related careers featured prominently in boys' lists of dream careers, whereas they did not appear in girls' lists at all.[75] The most likely causes of such early divergences in preferences and confidence levels are the lack of female role models in the STEM sector, gendered stereotypes of technology as a male occupation and hobby, and parents, teachers and the media being more likely to encourage boys to pursue STEM careers.[76]

Globally, women make up less than a third of all enrolees in ICT tertiary courses; a gender gap that is unmatched even in other male-dominated fields such as medicine.[77] The attrition rate for female tertiary students in these courses is disproportionately high and begins at a slow pace but accelerates swiftly the closer women get to graduation, which is often ascribed to a lack of female peers, competitiveness and gender discrimination.[78] Furthermore, a considerably larger proportion of women in STEM courses are studying natural sciences rather than applied sciences such as engineering and computer science.[79] The difference in skills between men and women also follows the same exponential trend. While there is a noticeable gap with basic skills such as using mobile phone apps or arithmetic formulas in spreadsheets, it widens considerably at more difficult levels, with men being four times more likely to have advanced ICT skills such as programming computers and coding computer software.[80]

Trends in employment are equally concerning. Globally, women constitute less than 30% of professionals in STEM and 24% of the digital sector.[81] Women are especially absent at the frontiers of technology, in fields such as artificial intelligence and machine learning.[82] Furthermore, even when women are present in these industries, they are more likely to hold lower-level and

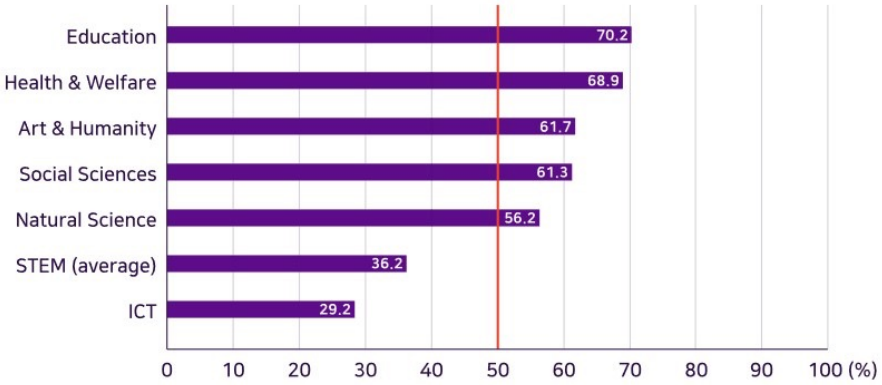

Figure 3. Global proportion of female enrolments by field of study. EQUALS, *I'd Blush If I Could,* 23.

administrative positions, and when women achieve managerial roles, they tend to be in staff rather than line positions that lead to executive roles.[83] Female employment in the ICT sector is plagued by the "leaky pipeline" problem, wherein women's participation decreases by age and as they move up the career ladder.[84] A range of causes have been identified for these high attrition rates, including: dominant male culture, lack of female support networks, long and inflexible working hours clashing with care duties, the gender pay gap, and low chances of career advancement.[85] Importantly, data shows that the percentage of women in ICT careers has dropped across the globe in recent decades, indicating that the gender divide is becoming more pronounced, not less so.[86]

In terms of technological innovation, women are significantly less likely to patent inventions, launch start-ups, and develop software. Women are responsible for only 7% and 2% of ICT patents across G20 countries and worldwide respectively.[87] While women's participation in patenting is increasing, at the current pace it will take approximately 60 years for women to grow to comprise half of all patented inventions in the world's five largest IP firms.[88] Women also lack training in business start-ups and are less likely to become ICT entrepreneurs, with only 10% of technology start-ups seeking venture capital funding having female founders.[89] In online software developer communities, the percentage of female users is often in the single digits, while software packages are overwhelmingly created by male-only teams, and women in these communities tend to favor viewing questions and answers and following other developers over responding to or posting their own questions and contributing code.[90]

[73] *ibid,* 21.

[74] EQUALS, *Taking Stock: Data and Evidence on Gender Equality in Digital Access, Skills, and Leadership* (United Nations University, 2019), 62, https://i.unu.edu/media/cs.unu.edu/attachment/4040/EQUALS-Research-Report-2019.pdf; *ibid*, 23.

[75] *ibid,* 63.

[76] Department of Industry, Innovation and Science, *Advancing Women in STEM* (Commonwealth of Australia, 2019), 13, https://www.industry.gov.au/sites/default/files/March%202020/document/advancing-women-in-stem-strategy.pdf.

[77] EQUALS, *I'd Blush If I Could,* 23.

[78] *ibid,* 24.

[79] EQUALS, *Taking Stock,* 74.

[80] EQUALS, *I'd Blush If I Could*, 24; Furszyfer Del Rio, Sovacool, and Martiskainen, "Controllable, Frightening, or Fun?" 2.

[81] *ibid,* 15.

[82] EQUALS, *Taking Stock*, 95.

[83] Policy Department for Citizen's Rights and Constitutional Affairs, *The underlying causes of the digital gender gap and possible solutions for enhanced digital inclusion of women and girls* (European Parliament, 2018), 20, https://www.europarl.europa.eu/RegData/etudes/STUD/2018/604940/IPOL_STU(2018)604940_EN.pdf.

[84] EQUALS, *Taking Stock*, 107.

[85] EQUALS, *I'd Blush If I Could,* 17.

[86] *ibid*, 15.

[87] OECD Directorate for Science, Technology and Innovation, *Bridging the Digital Gender Divide: Include, Upskill, Innovate* (OECD, 2018), 15, https://www.oecd.org/digital/bridging-the-digital-gender-divide.pdf.

[88] EQUALS, *I'd Blush If I Could*, 100.

[89] OECD Directorate for Science, Technology and Innovation, *Bridging the Digital Gender Divide*, 96.

Lastly, the 2019 Digital Inclusion Index provides some insights into the scope of the digital gender divide in Australia. Compared to men, women score lower across all three measured dimensions of digital inclusion; access, affordability and digital ability.[91] Furthermore, digital inclusion scores are substantially lower for Australians who are low-income, unemployed, without tertiary education, Indigenous, disabled, older, and living in rural areas, highlighting the need for an intersectional response to the digital gender divide.[92] Taken together, this lack of representation and diversity in ICT education, employment, skills and innovation mean that women often cannot influence the very technologies that are shaping their lives.

Privacy and safety

The perceived security risk and invasion of privacy are further reasons why some people may balk at bringing newer technologies into their homes and around their children. Smart technologies in the home can generate a vast amount of sensitive data on household members' health and lifestyles, which may be scrutinised or sold to a third party by manufacturers, as evidenced by Google and Amazon admitting to employees listening to recordings captured by digital voice assistants in homes.[93] This is a particular area of concern for products such as childcare robots, children's wearables and internet-connected toys, which have proven vulnerable to data breaches on multiple occasions. Such incidents include the 2015 VTech breach of a database containing data on nearly 3 million children and the 2017 CloudPets breach of over 800,000 accounts, which leaked information regarding children's names, profile photos, birthdates, and voice recordings. [94]

Smart homes present an increasingly appealing target for cyber-attacks due to the vulnerability of various Internet of Things (IoT) devices, which tend to have limited storage and computing capacity, and their interconnected nature.[95] Hackers can access an entire network and the data stored within simply by targeting the 'weakest link'; the device with the poorest security.[96] Through the use of ransomware, which has been increasing in both occurrence and variety, hackers can extort funds from victims by blocking access to or controlling the home network untilresidents pay to restore access.[97] In the most extreme situations, hackers can cause physical harm to occupants by hijacking devices and causing pipes to burst, increasing or decreasing the temperature in the home, or turning on stoves while turning off smoke and carbon monoxide alarms.[98]

Smart home technology may also facilitate domestic violence and harassment, as partners with access to the system or technologically-adept stalkers can utilise this network to track the movements of household residents, remotely surveil them through hidden cameras, lock them within their own homes, and otherwise control or abuse their targets.[99] In countries with relatively higher diffusion of smart home technologies, domestic violence responders have reported an increase in cases involving e-locks, internet-connected cameras, thermostats, and other devices.[100] Women are disproportionately more likely to be the targets of such technology-based abuse, which may influence their willingness to purchase and utilise such products; however, this is not an area of research which has received much scholarly attention to date.[101]

[91] J Thomas et al., *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2020* (Melbourne: RMIT and Swinburne University of Technology, 2020), 18, https://apo.org.au/sites/default/files/resource-files/2020-10/apo-nid308474.pdf.

[92] *ibid,* 5.

[93] Furszyfer Del Rio, Sovacool, and Martiskainen, "Controllable, Frightening, or Fun?" 10.

[94] Donell Holloway, "Surveillance Capitalism and Children's Data: The Internet of Toys and Things for Children," *Media International Australia* 170, no. 1 (February 2019): 33, doi: 10.1177/1329878X19828205.

[95] Ignacio Rodriguez-Rodriguez et al., "Towards a Holistic ICT Platform for Protecting Intimate Partner Violence Survivors Based on the IoT Paradigm," *SYMMETRY-BASEL* 12, no. 1 (January 1, 2020): 7, doi: 10.3390/sym12010037.

[96] Thanaphol Pattanasri, "Mandatory Data Breach Notification and Hacking the Smart Home: A Legal Response to Cybersecurity," *QUT Law Review* 18, no.2 (2018): 273, http://heinonline.org/HOL/Page?handle=hein.journals/qutlj18&div=26.

[97] *ibid,* 274.

[98] *ibid.*

[99] Rodriguez-Rodriguez et al., "Towards a Holistic ICT Platform," 5; Strengers et al., "Protection, Productivity and Pleasure," 8.

[100] EQUALS, *I'd Blush If I Could*, 29.

[101] *ibid,* 28.

	ICT MINISTRY	DRAFT LEGISLATION	NO LEGISLATION	NO DATA
CYBERCRIME LEGISLATION	140 (72%)	18 (9%)	35 (18%)	1 (1%)
DATA PRIVACY AND PROTECTION	112 (58%)	19 (10%)	40 (21%)	23 (12%)

Figure 4. Status of cybercrime and data privacy laws worldwide. EQUALS, *Taking Stock,* 117.

In 2020, the Australian government released a Code of Practice to encourage manufacturers to improve the security of their IoT devices. This code contains guidelines for secure passwords, security patches, reporting vulnerabilities and protecting and deleting consumers' personal data, but is also a voluntary code.[102] While more time and research are needed to fully determine the effectiveness of this Code, evidence from overseas suggests that it may be fairly ineffective. The United Kingdom released a similarly voluntary Code of Practice in 2018, but has since found it to be insufficient for ensuring greater consumer protection.[103] It is now moving to impose a mandatory code, with laws requiring manufacturers to implement certain security features in all of their internet-connected devices.

Acceptance of technology

The amount of in-depth research which examines parents' acceptance of childcare technologies in home settings is vanishingly small, despite parents being the primary purchasers of such products. Mothers' hesitations and concerns constitute a barrier to greater adoption of potentially labour-saving technologies, and as such require deeper investigation. Research generally shows that mothers view devices such as tablets and smartphones as useful tools, which can be used to educate, distract, and provide downtime for children, and allow mothers a period of respite from caring duties.[105] On the other hand, some mothers also express concern at the potentially addictive and sedentary nature of screen-viewing and worry that such devices reduce their child's opportunities for face-to-face social interactions, resulting in a struggle to find the correct balance between their child's screen-time and other activities.[106]

In terms of childcare robots, the small amount of available research shows that parents generally hold positive views of robots, especially when compared to screen-based technologies. Parent attribute such views to robots reducing the strain on children's eyes compared to screen-viewing, and robots having pre-programmed child-friendly content, compared to other 'babysitting tools' such as YouTube, which may inadvertently recommend inappropriate content to children.[107] However, several parents also worried that using such robots would hinder their child's development of social skills, and expressed discomfort at the possibility of a robot influencing their child during a vital stage in their growth and development.[108] Furthermore, a concern which appears to be unique to robots is the worry that a child may grow to prefer the robot over their parent, due to the robot's humanlike features. Some parents expressed concern that their child may treat the robot as an alternative parent and choose to spend time or show affection to it instead, reducing their opportunities to interact and bond with their children.[109]

Relating to this concern of being replaced, a phenomenon which is worth considering is maternal gatekeeping. Maternal gatekeeping is defined as beliefs and behaviours which inhibit collaborative domestic work between mothers and fathers by preventing fathers from engaging in and learning from caring for their home and children.[110] Maternal gatekeeping involves actions by mothers such as setting impossibly high and unbending standards for fathers' domestic work, redoing fathers' tasks, or criticizing fathers' work.[111] Scholars have suggested that such gatekeeping behaviours are the result of gender stereotypes, which construct the home as the woman or mother's domain, thus giving her power and privilege over men in this space, and a sense of indispensability.[112] Increased paternal involvement in domestic labour may then be perceived as a threat to mothers' authority in 'their' sphere, challenging their self-identity as a woman and triggering feelings of regret and guilt for 'neglecting their role' as a mother.[113] Hence, the questions which should be asked here are: if some mothers are unwilling to delegate childcare responsibilities to their own partners, what is the likelihood that they would allow robots to care for their children? How do other factors, such as the robot's limited parenting capabilities compared to another human, influence these attitudes? More research is needed to illuminate this topic.

[102] Department of Home Affairs, *Code of Practice: Securing the Internet of Things for Consumers* (Commonwealth of Australia, 2020), https://www.homeaffairs.gov.au/reports-and-pubs/files/code-of-practice.pdf.

[103] Department for Digital, Culture, Media & Sport, *Code of Practice for Consumer IoT Security* (UK Government, 2018), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/971440/Code_of_Practice_for_Consumer_IoT_Security_October_2018_V2.pdf.

[104] Kayleen Manwaring and Roger Clarke, "Are your devices spying on you? Australia's very small step to make the Internet of Things safer," *The Conversation*, September 11, 2020, 5:42 p.m. AEST, https://theconversation.com/are-your-devices-spying-on-you-australias-very-small-step-to-make-the-internet-of-things-safer-145554.

[105] Georgina F. Bentley, Katrina M. Turner, and Russell Jago, "Mothers' Views of Their Preschool Child's Screen-Viewing Behaviour: A Qualitative Study," *BMC Public Health* 16, no. 1 (December 2016): 5, doi: 10.1186/s12889-016-3440-z.

[106] Michelle Neumann, Guy Merchant, and Cathy Burnett, "Young children and tablets: the views of parents and teachers," *Early Child Development and Care* 190, no. 11 (2020): 1758, doi: 10.1080/03004430.2018.1550083.

[107] Chaolan Lin, Selma Šabanović, Lynn Dombrowski, Andrew D. Miller, Erin Brady, and Karl F. MacDorman, "Parental Acceptance of Children's Storytelling Robots: A Projection of the Uncanny Valley of AI," *Frontiers in Robotics and AI* 8, (2021): 7, doi: 10.3389/frobt.2021.579993.

[108] *ibid,* 9.

[109] *ibid,* 8.

[110] Sarah M. Allen and Alan J. Hawkins, "Maternal Gatekeeping: Mothers' Beliefs and Behaviors That Inhibit Greater Father Involvement in Family Work," *Journal of Marriage and Family* 61, no. 1 (February 1, 1999): 200, doi: 10.2307/353894.

[111] *ibid,* 203.

[112] *ibid,* 201-4.

[113] *ibid,* 204.

Section 3: Opportunities and solutions

Case Study 1: Gerontechnology and smart homes

Introduction

Rising life expectancies and declining fertility rates worldwide have raised concerns about aging populations and the care deficit, with the United Nations predicting that the global population of people aged 60 years and older will reach 2 billion by 2050.[114] The worldwide shortage of care workers has already led countries such as Japan and Germany to invest in technology as a potential solution for the care demands of the elderly living in long-term care facilities.[115] However, facilities such as nursing homes can be expensive and placement in such facilities, especially when against the individual's own wishes, is associated with a higher likelihood of social isolation and depression.[116] Hence, a number of older people may prefer the comfort and familiarity of their own homes, where they can maintain a higher degree of independence. A range of innovations have thus been developed to support this lifestyle, which includes smart homes and assistive robots. The field that these innovations fall under is called "gerontechnology"- a portmanteau of gerontology and technology- for the design of technology which supports older persons to live independently and in comfort, safety, and good health.[117]

Smart homes

While there is no universally-agreed upon definition of smart homes, a useful definition for the purposes of this report is a residence equipped with computing and information technology that, from within the home and through connections beyond it, can anticipate and respond to occupants' needs and promote their convenience, comfort, entertainment, and security.[118]

The smart home is composed of integrated systems which communicate with each other and act together. Environmental sensors remotely monitor the home's temperature and humidity and detect smoke, while wearable biomedical sensors automatically and continuously collect real-time measurements of physiological signals including body temperature, blood pressure, blood oxygen levels, respiration rate and heart rate.[119] Smart textile technologies in particular have thepotential to be an inexpensive, unobtrusive method of gathering health data, and as this technology continues to evolve, such sensors can increasingly be fabricated by more conventional means such as knitting, printing, stitching, and weaving.[120]

Once the aforementioned information is collected, it is then analysed and feedback is sent to the user; or to appliances such as the air conditioner, humidifier and oxygen generator in order to activate them and adjust the home environment.[121] Data can also be sent to carers, service providers, or healthcare personnel in remote healthcare facilities so that the occupants' condition can be monitored and to ensure a swift response in the case of an emergency.[122] Furniture around the house can also assist in this process, such as smart chairs or smart beds that can monitor a person's sleep patterns.[123] Additionally, motion sensors are relatively small and low-power devices which can be embedded in t-shirts, armbands and socks to receive information about the wearer's gait, and alongside items such as a smart walking stick, can recognise if an elderly person suffers a fall.[124] These sensors transmit the information to the house's system, which attempts to speak to the occupant if a fall occurs and alerts emergency services if necessary.[125]

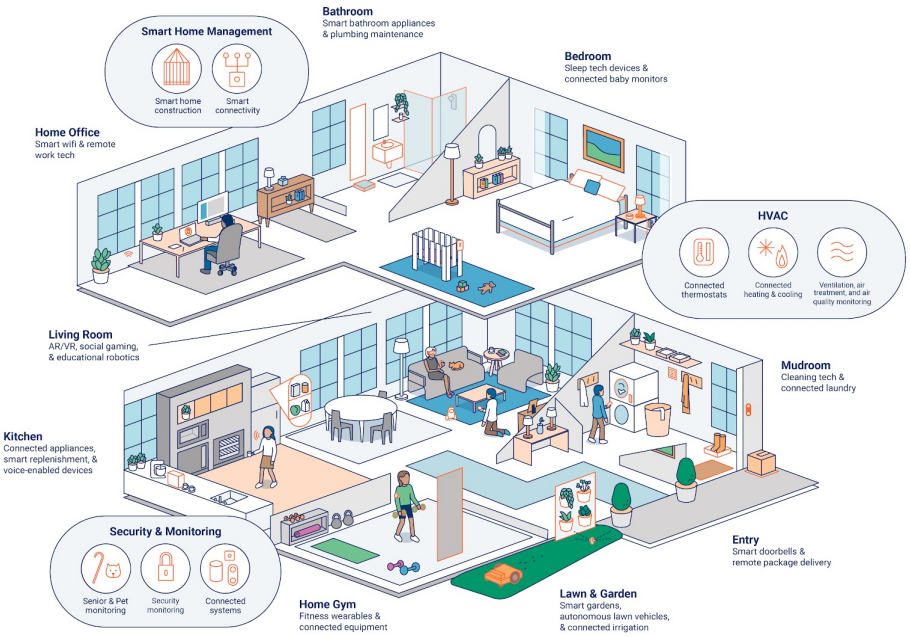

Figure 5. An example of an integrated smart home system and its capabilities. "The Future of the Smart Home," CBInsights, published December 17, 2020, https://www.cbinsights.com/research/report/smart-home-future-trends/.

[114] Lili Liu et al., "Smart Homes and Home Health Monitoring Technologies for Older Adults: A Systematic Review," *International Journal of Medical Informatics* 91 (July 2016): 45, doi: 10.1016/j.ijmedinf.2016.04.007.

[115] Parks, "Lifting the Burden," 101.

[116] Liu et al., "Smart Homes and Home Health Monitoring Technologies," 46.

[117] *ibid.*

[118] Sadowski, Strengers, and Kennedy, "More Work for Big Mother," 4

[119] Majumder et al., "Smart Homes for Elderly Healthcare," 2.

[120] *ibid.*, 22.

[121] *ibid.*, 3.

[122] *ibid.*, 2.

[123] *ibid.*, 6.

[124] *ibid.*, 13.

[114] Michael Decker, "Caregiving Robots and Ethical Reflection: The Perspective of Interdisciplinary Technology Assessment," *AI & SOCIETY* 22, no. 3 (January 2008): 328, doi: 10.1007/s00146-007-0151-0.

Another concept which has recently been introduced is that of the robot-integrated smart home (RiSH). This concept combines home service robots with the smart home system in order to compensate for each other's weaknesses. The robot's sensory capabilities are rather limited, and their auditory perception is often incapable of recognising event sounds in the home, whilst the smart home system cannot physically interact with much of the home's contents or residents.[126] Popular robot assistants on the market include Aibo, Care-o-Bot, and Paro. These robots can remind owners to eat, drink, and take their medication, and act as mobility aids and communication tools (some with videophones and camera systems).[127] The Care-o-Bot II is capable of fetching and carrying, basic cleaning tasks, setting the table, and can even multitask these duties.[128] Its learning algorithm also allows it to learn about and adapt to occupants' behaviour and manoeuvre in unknown environments.[129] Through integrating such robots into the smart home system, these robots can access a significantly larger pool of data, communicate with remote caregivers and leverage the smart home's sensor network, thus improving their performance. [130]

Applications for the second shift

Smart technology is growing increasingly common in households, ranging from voice-activated assistants such as Alexa and Google Assistant to a fully networked system. The smart home market was estimated to have diffused to 7.5% of households globally in 2018, and is projected to be worth US $53 billion by 2022.[131] While individual smart home technologies ranging from smart speakers to smart fridges may be found in various households and may be able to connect to and control other devices, the advantage of smart homes developed specifically for the elderly is the integrated and holistic nature of these systems.

While households without elderly residents may not require such extensive physiological monitoring for all occupants, unobtrusive and low-cost sensors in clothing may be useful for tracking the health of young children and people with disabilities or other health concerns, and alerting occupants if any incidents occur. Furthermore, while many currently available products are marketed as standalone products, developed only for one or a few specific tasks, the literature on gerontechnology offers a unique solution for an integrated system; one that combines these technologies to produce benefits which are greater than the sum of its parts. Adapting concepts drawn from gerontechnology may therefore offer a means of decreasing the time women spend on domestic work by implementing a comprehensive system which automates and independently oversees a significant portion of women's typical household management labour, and carries out a range of basic household chores.

Case Study 2: Social robots in education

Capabilities and benefits

Educational robots are a broad category which includes toy robots, robotics kits, and social robots. Toy robots are commercially available robots designed for entertainment, and robotics kits are programmable construction kits which enable children to create, build, and/or program robots, but social robots are the focus of this case study, due to their capability for deeper engagement with children.[132] Social robots are autonomous or semiautonomous robots based on artificial intelligence which can communicate and interact with people and follow behavioural norms.[133] When deployed in an educational space, these social robots are intended to provide a form of "edutainment" or "stealth education"; creating an enjoyable, game-like learning environment to engage children and develop their social and academic skills while simultaneously entertaining them.[134]

To assist in the process of learning, social robots can be designed to fulfil one of several different roles. When intended to function as a tutor, robots often act as assistants to teachers in classrooms, and provide hints, tutorials, and supervision to children.[135] Robots can also act as a learning companion or peer- which can be less intimidating to young students compared to a robot tutor- and are designed to assist children's learning in a collaborative rather than didactic manner.[136] Finally, robots can behave as a novice, thus placing children in the role of the teacher to capitalise on the protégé effect, wherein students can boost their own confidence and reinforce their understanding of course materials through teaching the robot.[137] Examples of teachable robots are the care-receiving robot first introduced in Japanese classrooms, who was designed to make deliberate mistakes in English vocabulary until it was 'taught' by children who corrected its errors, or the social robot with poor handwriting utilised in several Portuguese primary schools, who improved when students accurately assessed its letters and demonstrated the correct shapes.[138]

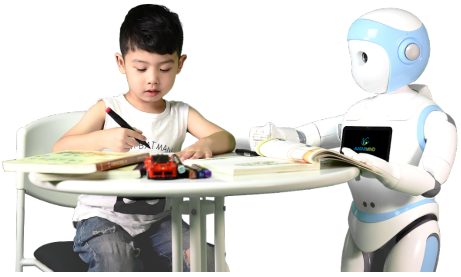

Figure 6. iPal: a robot designed by AvatarMind as an educational and entertaining companion for children. "AvatarMind iPal Robot Family," AvatarMind Robot Technology, https://www.ipalrobot.com/.

[126]Ha Manh Do et al., "RiSH: A Robot-Integrated Smart Home for Elderly Care," *Robotics and Autonomous Systems* 101 (March 2018): 75, doi: 10.1016/j.robot.2017.12.008.

[127]*ibid.*

[128]Parks, "Lifting the Burden," 103.

[129]*ibid.*

[130]Do et al., "RiSH," 75

[131]Furszyfer Del Rio, Sovacool, and Martiskainen, "Controllable, Frightening, or Fun?" 1.

[132]Sung Jung and Eun-sok Won, "Systematic Review of Research Trends in Robotics Education for Young Children," *Sustainability* 10, no. 4 (March 21, 2018): 2, doi: 10.3390/su10040905.

[133]Junko Kanero et al., "Social Robots for Early Language Learning: Current Evidence and Future Directions," *Child Development Perspectives* 12, no. 3 (September 2018): 146, doi: 10.1111/cdep.12277.

[134]Hsien-Sheng Hsiao et al., "'iRobiQ': The Influence of Bidirectional Interaction on Kindergarteners' Reading Motivation, Literacy, and Behavior," *Interactive Learning Environments* 23, no. 3 (May 4, 2015): 271, doi: 10.1080/10494820.2012.745435.

[135]Tony Belpaeme et al., "Social robots for education: A review," *Science Robotics* 3, no. 21 (2018): 5, doi: 10.1126/scirobotics.aat5954.

[136]*ibid.*, 6.

[137]*ibid.*

Research into educational robotics and their various applications has found numerous benefits for children's learning. Social robots have been shown to enhance learning in STEM classes, improve spatial orientation, meta-cognitive thinking, collaborative skills, problem-solving, critical thinking, second language learning (including in areas such as speaking ability, pronunciation, confidence, storytelling skills, and vocabulary acquisition), motor skills (especially handwriting), and children's motivation, satisfaction, and interest in learning, especially towards technology and science.[139] Some social robots can even monitor children's development in learning over time and provide personalised support to each child.[140] Additionally, social robots have had a demonstrably positive impact on building the social skills of children with autism spectrum disorders (ASD), possibly due to some designs of social robots being more patient and predictable, and less intimidating compared to a human teacher.[141] These robots are capable of teaching children with ASD about emotions, and assist in developing their vocabulary and communication skills.[142]

Social robots have also consistently outperformed more traditional digital technologies in terms of children's learning gains. Compared to technologies such as web-based applications and audio materials on tablets and computers, children's concentration, motivation and academic performance are generally improved when using social robots as a platform for learning.[143] Researchers have theorized that these results are due to social robots more closely resembling human teachers, as they are physical agents- often with humanoid features- who are capable of semi-natural social interactions with children.[144] Seymour Papert, one of the pioneers of artificial intelligence, posits in his Constructionist Theory that robots act as a bridge between abstractions and concrete realizations or representations in the real world.[145] Through hands-on interactions with the social robot, children formulate plans or concepts in their heads, execute these solutions in their physical reality, and receive feedback from the robot in real-time.[146] Another advantage of the physically embodied nature of social robots is their capacity to perform actions and gestures.[147] Gestures are shown to be particularly effective in enhancing learning and concentration for young children and people learning second languages.[148]

Applications for the second shift

Social robots in the education sector are a promising source of knowledge and data for the design of more general childcare robots in the home. Current childcare robots on the market are still quite basic; they have some monitoring, communication and entertainment capabilities, but function more as a combination of an amusing distraction and a surveillance device than a tool for building children's skills and easing parents' care obligations.[149]

On the other hand, while technological advancements have not reached the point where robots can effectively replace teachers, social robots can nevertheless supplement the material learned at kindergarten or school, providing the focused, one-on-one tutoring that children may not be able to receive while in the classroom with other students. Current educational robots still tend to be rather specialized; built for assisting children's learning through a fairly narrow range of structured activities and games. Nevertheless, as an advanced field of robotics which combines state-of-the-art research in artificial intelligence, machine-learning algorithms and real-time control issues, it holds significant potential for growth.[150] Hence, drawing from the field of educational robotics presents an opportunity for significantly enhancing the home childcare robots' capabilities; combining the educational robot's more specialized, sophisticated teaching functions with the home childcare robot's broader skillset. This synthesis would potentially allow these robots to take on a greater share of parents' typical childcare duties, such as assisting children with homework and building their knowledge and abilities through play.

On the research side, Lee et al.'s study of South Korean families found that dual-earner parents worried that their work obligations reduced the time they were able to nurture their child's social and emotional development, and so favored robots who could fulfil the role of playmate and teach children social skills.[151] Conversely, single-income families tended to prioritise the educational functions of social robots.[152] While these results obviously cannot be generalised to all households, the authors also pointed out the serious lack of research into parents' perceptions of childcare robots in home settings.[153] Indeed, the variation in parents' preferences for social robots and their functions across a range of family compositions, parenting styles, and paid employment dynamics has rarely been studied despite parents being the target customers for the burgeoning childcare robot market. Thus, more nuanced data on how childcare robots should be designed to best accommodate parents' needs is difficult to provide at this point, but is a clear first step for the future development of childcare robots.

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[139] *ibid;* Einat Brainin, Adina Shamir, and Sigal Eden, "Robot Programming Intervention for Promoting Spatial Relations, Mental Rotation and Visual Memory of Kindergarten Children," *Journal of Research on Technology in Education*, (2021): 2, doi: 10.1080/15391523.2020.1858464; Hsiao et al., "iRobiQ," 271; Kristin S Fuglerud and Ivar Solheim, "The Use of Social Robots for Supporting Language Training of Children," *Studies in Health Technology and Informatics* 256 (2018): 402; Rina Zviel-Girshin, Adi Luria, and Chait Shaham, "Robotics as a Tool to Enhance Technological Thinking in Early Childhood," *Journal of Science Education and Technology* 29, no. 2 (2020): 295, doi: 10.1007/s10956-020-09815-x.

[140] Fuglerud and Solheim, "The Use of Social Robots," 402.

[141] Suleman Shahid, Emiel Krahmer, and Marc Swerts, "Child–Robot Interaction across Cultures: How Does Playing a Game with a Social Robot Compare to Playing a Game Alone or with a Friend?," *Computers in Human Behavior* 40 (November 2014): 87, doi: 10.1016/j.chb.2014.07.043.

[142] Lee, Lee, and Lee, "Can Robots Help Working Parents," 2.

[143] Belpaeme et al., "Social robots for education," 1.

[144] Paul Vogt et al., "Child-Robot Interactions for Second Language Tutoring to Preschool Children," *Frontiers in Human Neuroscience* 11 (2017): 2, doi: 10.3389/fnhum.2017.00073.

[145] Brainin, Shamir, and Eden, "Robot Programming Intervention," 3.

[146] *ibid.*, 2.

[147] Kanero et al., "Social Robots for Early Language Learning," 147.

[148] *ibid*.

[149] Alice LaPlante, "Robot Nannies Are Here, But Won't Replace Your Babysitter -- Yet," *Forbes*, March 29, 2017, 10:44 EDT, https://www.forbes.com/sites/centurylink/2017/03/29/robot-nannies-are-here-but-wont-replace-your-babysitter-yet/. In fact, professor of computer science Henrik Christensen summarized these robots' functions as "nannycams on steroids".

[150] Guy Keren and Marina Fridin, "Kindergarten Social Assistive Robot (KindSAR) for Children's Geometric Thinking and Metacognitive Development in Preschool Education: A Pilot Study," *Computers in Human Behavior* 35 (June 2014): 403, doi: 10.1016/j.chb.2014.03.009.

[151] Lee, Lee, and Lee, "Can Robots Help Working Parents," 3.

[152] *ibid*.

[153] *ibid.*, 2.

Closing the digital gender divide

The recommendations, policies, and practices discussed below may not directly impact women's domestic work burdens, but they nevertheless have the power to positively influence the context and nature of the technology used in homes. Closing the digital gender divide has the potential to increase women's usage of and proficiency in new technologies, and encourage the creation of products which better reflect the diverse needs and characteristics of consumers.

Evidence shows that frequent early exposure to technology can boost motivation and perceptions around digital skills, and normalises female use of technology.[154] As such, technology skills should be incorporated into curriculums at early primary or even pre-primary levels, as research indicates that the gender divide in technology self-efficacy begins as early as 6 years old in girls.[155] In secondary education, technology classes can be made mandatory to combat the trend of girls being significantly more likely to opt out of STEM courses. Technology courses can also be made mandatory for all degrees- not just ICT-related fields- in tertiary education, due to the increasing importance and relevance of technology skills in a range of careers. Enrolment in ICT fields at the tertiary level can be incentivised through scholarships, and a range of apprenticeship schemes and internships offered to women to assist with a smoother transition into the workforce. This should also be supported by connecting girls and women with female mentors through computing clubs and other extracurricular activities, or through a designated mentorship programme, to help build skills and networks.

Outside of formal educational spaces, technology-focused after-school clubs, camps, and extracurricular activities are important for promoting enthusiasm for digital learning in an entertaining and relaxed environment. Other innovative pathways for building digital skills are coding bootcamps, Massive Open Online Courses (MOOCs), and hackerspaces or makerspaces. Coding bootcamps are project-based intensive training programmes consisting of lectures, online exercises and collaborative work based around practical programming that aims to build career development skills.[156] MOOCs are a flexible and free or low-cost form of e-learning which allows students to choose their own courses and complete them at their own pace, and can draw over 150,000 students to a single course.[157] Feminist and inclusive makerspaces offer a space where women with similar interests in technology can collaborate, teach, learn, work, innovate, and share knowledge.[158]

Other recommendations for closing the digital gender divide include a range of stakeholders, from technology companies to policy makers and academia, setting quotas and time-bound hiring targets for women, in both their general workforce and in leadership positions. Government-funded scholarships for ICT training programmes, especially when funding covers living expenses, transport, and supplies, can also assist women who are seeking career advancement or changes. Workplaces that offer flexible work arrangements, better childcare benefits and family leave options are more likely to retain women with care obligations in the technology industry. Lastly, collection and reporting mechanisms for ICT-related data should be improved by adding gender dimensions to data that currently is not gender-disaggregated, and published in periodical reports which measure progress toward digital gender equality.

In Australia, the government has invested $17 million in 2015 under the National Innovation and Science Agenda and another $6 million in 2018-19 to support women's participation in STEM education and careers; and has also committed $31.2 million to STEM internships and post-school career advice.[159] Furthermore, the government has invested $25 million to increasing female Aboriginal and Torres Strait Islander participation in STEM, of which $20 million will go to constructing an Indigenous Girls STEM Academy to support up to 100 girls each year, and $5 million to the Stronger Smarter Institute to support the training of up to 100 female Aboriginal and Torres Strait Islander STEM teachers.[160] Other initiatives supported by the government include the Curious Minds summer schools for high achieving female Year 9 and 10 students, and the Women in Cyber initiative to encourage women to pursue careers in cyber security.[161] Though the Australian government has made significant steps toward addressing the gender gap in STEM, data suggests that there is still much work to be done, with the 2021 STEM Equity Monitor showing that while positive changes have occurred over time in several categories, these changes tend to happen at a glacial pace.[162]

[154] *ibid.*

[155] EQUALS, *I'd Blush If I Could,* 40.

[156] EQUALS, *Taking Stock*, 70.

[157] *ibid,* 73.

[158] *ibid*, 73-4.

[159] OECD Directorate for Science, Technology and Innovation, *Bridging the Digital Gender Divide*, 104.

[160] United Nations Children's Fund (UNICEF), *Towards an equal future: Reimagining girls' education through STEM* (New York: United Nations, 2020), 17, https://2b37021f-0f4a-4640-8352-0a3c1b7c2aab.filesusr.com/ugd/04bfff_d6ffe9bee8b24d7a814805d0f8c99db8.pdf.

[161] "Government initiatives," Department of Industry, Science, Energy and Resources, https://www.industry.gov.au/data-and-publications/australias-tech-future/government-initiatives.

[162] Department of Industry, Science, Energy, and Resources, *STEM Equity Monitor: Data Highlights 2021* (Commonwealth of Australia, 2021), https://www.industry.gov.au/sites/default/files/May%202021/document/stem-equity-monitor-highlights-report-2021_0.pdf.

Conclusion

As the 20th century's 'industrialisation of the home' has demonstrated, technology alone has not been a panacea for women's domestic burdens. Indeed, the gendered division of domestic labour is a complex social problem which requires multifaceted responses on multiple fronts. Technology, however, has long been overlooked as one such tool to add to this toolkit. In investigating the potential for technology to assist and reduce women's household work, this report did not provide a specific list of recommendations, supported by extensive and rigorous research. This is because, as this report has repeatedly demonstrated, the paucity of research on this topic is a frequently reoccurring theme; the literature and evidence- if it exists at all- is still in its infancy.

Instead, this report has endeavoured to explore the current landscape of domestic technologies and their labour-saving potential; highlighting areas of concern and gaps in the literature, as well as examining related fields of technology which may offer valuable lessons and guide future research. Hence, this report serves as the springboard for further investigations into this topic; technology may hold significant promise for reducing women's 'second shift', but ultimately it is an area which requires much deeper and careful study before it can be marketed and utilised as such.

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