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Analysis of Barbie medical and science career dolls: descriptive quantitative study

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ABSTRACT

OBJECTIVES

To identify Barbie brand dolls that had medicine and science themed professions in comparison with other career dolls and to determine their accuracy in meeting clinical and laboratory safety standards.

DESIGN

Descriptive quantitative study.

SETTING

Visual and data analysis of web searches.

MAIN OUTCOME MEASURES

To identify the kinds of medical and scientific subspecialties that the Barbie dolls (and a comparison doll group) worked in; and to determine whether these medical professional and scientist dolls met laboratory and clinical safety standards. Additional data about doll demographics (ie, age, ethnic group, and sex) were also collected.

PARTICIPANTS

92 Barbie brand dolls were analyzed: doctor (n=53), scientist (n=10), science educator (n=2), nurse (n=15), dentist (n=11), and paramedic (n=1). 65 non-Barbie brand dolls were also analyzed for comparison purposes: doctor (n=26), scientist (n=27), nurse (n=7), dentist (n=2), engineer (n=2), and magnetic resonance imaging (MRI) technician (n=1) dolls.

RESULTS

Barbie brand medical professional dolls (n=80) largely treated children (66%, n=53/80), with only three (4%) medical professional dolls being directly depicted working with adults. Of the 12 scientist Barbie brand dolls, none met all proper personal protective equipment requirements related to hair and clothing.

Barbie brand dolls often came with items, such as laboratory coats, microscopes, stethoscopes, and glasses, that children stereotypically associate with doctors and scientists. While comparison dolls offered a wider range of age and ethnic groups than the Barbie doll group did, the dolls similarly struggled to portray a wide range of medical and scientific subfields and most comparison dolls did not wear proper personal protective equipment.

CONCLUSIONS

Medicine and science themed dolls help to inspire tomorrow's medical professionals and scientists. All toy companies should ensure that future medical professional and scientist dolls meet clinical and laboratory safety standards and diversify the types of medical and scientific professions represented (especially among male dominated fields). For young girls' sakes as much as her own, Barbie must keep shattering glass ceilings.

Introduction

If Barbie were a real woman, she would have a can of alphabet soup's worth of degree titles (ie, PhD, MD, DO, OD, DNP, DDS, DVM, JD, MSc, and an MBA) after her name. The ever-popular fashion doll has been everything from a construction worker, teacher, and veterinarian to a judge, scientist, and medical doctor. By those metrics alone, she has more than lived up to the brand's former motto that "We girls can do anything." Yet, Barbie is far from the only woman reshaping the workforce. In the US and the UK, women now comprise 37.1% and 48.0% of all practicing physicians, respectively.^{1 2} With women beginning to dominate American and British medical school applications, these numbers are only expected to increase further.^{3 4} Similarly, women now account for more than half of all US and UK dental school students.⁵ Women continue to dominate in terms of numbers in the nursing profession: 88% and 89% of nurses in the US and UK, respectively, are female.^{7 8} From bachelors to doctorates, women earn more than half of all biological and medical research related degrees.³ The growing number of women within medicine and science offers more than only the chance for sex parity in traditionally male dominated fields, but also the opportunity to positively impact women's health on a large scale. Women's health issues, including female specific health conditions and diseases that overwhelmingly affect women, remain underfunded and under-researched.¹⁰ Female researchers have the power to change that deficit. Patients of both sexes have also benefited from women's growing presence within medicine because patients who have been treated by female surgeons are less likely to die or have negative acute and chronic outcomes after surgery than

WHAT IS ALREADY KNOWN REGARDING THIS TOPIC?

Sociologists have given children medical and scientist Barbie dolls to understand how they affect children's views of science and medicine and their perceived ability to pursue them as careers

No previous studies have analyzed Barbie medical professional and scientist dolls to determine the kinds of professions they hold and their professional accuracy

WHAT DOES THIS STUDY ADD?

This study analyzed Barbie medical professional and laboratory scientist dolls through the perspective of a medical researcher experienced in laboratory and desk work

Parents and children often do not realize how few medical and scientific specialties are represented or whether proper personal protective equipment is used

This study identifies flaws current dolls have and offers suggestions that toy companies could use to create better, more accurate, and professionally diverse medical professional and scientist dolls

patients treated by male surgeons are.^{11 12} Although the reasons for these improvements in outcome can only be speculated, they prove that women have more than earned their place in medicine.

Doctor, scientist, nurse, paramedic, and dentist Barbie dolls are more than mere pink playthings, but definite symbols of some of the most important careers that girls can aspire to one day hold, careers that their foremothers fought for them to access. Yet, these dolls do more than raise awareness. They embody society's ideas of who and what medical professionals and scientists are. As such, Barbie dolls can unintentionally spread misconceptions about medicine and science, most often via their appearances. Mattel openly seeks to inspire girls' future professional aspirations with their Barbie career dolls.¹³⁻¹⁵ If Barbie wishes to be an accurate mirror for young girls to reflect their medical and scientific career aspirations on, then she needs to practice many kinds of medicine and science and meet standard hospital and laboratory safety requirements.

This study had two main objectives: to identify the kinds of medical and scientific fields, including subspecialties, that the Barbie dolls (and a comparison group) worked in; and to determine whether these medical professional and scientist dolls met laboratory and clinical safety standards. Additional data about doll demographics (ie, age, ethnic group, and sex) were also collected.

Methods

Study design

I used visual observation and analysis of Barbie brand and comparison dolls in this descriptive quantitative study to identify the types of medical and science professions career dolls were depicted practicing and their adherence to clinical and laboratory safety standards. All data were collected and analyzed from July to November 2023 by a single author. Barbie brand dolls were identified using Google search results. Amazon, Walmart, eBay, Mattel, Barbie Wiki, and BarbieDB web pages were all consulted to find information about the name, year of production, and demographics of each doll (ie, age, ethnic group, and sex). Dolls, doll clothing and accessories, and any related packaging were visually analyzed to determine the doll's career, whether the clothing and accessories met clinical and laboratory safety standards, and what types of patients (if any) the dolls were designed to work with. Results were identified using the search terms "Doctor Barbie," "Dr. Barbie," "scientist Barbie," "Doctor Ken," "Dr. Ken," "nurse Barbie," "nurse Ken," "dentist Barbie," "dentist Ken," "doctor," "scientist," "science," "science teacher," "nurse," "dentist," and "STEM." Many of the career dolls in both groups came with smaller dolls modelled after babies and children. Unless these dolls were specifically depicted taking part in scientific or medical careers (ie, Chelsea Can Be dolls), then demographics and other data about them were not analyzed.

Barbie may be the focus of this research, but she is far from the only doll on toy store shelves. A separate

group of 65 dolls and doll-like toys was analyzed for comparison purposes. These comparison dolls were analyzed using the same objectives as the Barbie dolls were. Demographic data were also collected for each comparison doll. Laboratory scientist, doctor, nurse, dentist, engineer, and magnetic resonance imaging (MRI) technician dolls were analyzed. Comparison participants were identified using Google, Amazon, Walmart, and eBay webpages, as well as Yo Joe!, Bratz Wiki, and MHcollector databases. The search terms "doctor doll," "scientist doll," "science doll," "nurse doll," "dentist doll," "STEM doll," "doctor," "scientist," "science teacher," "nurse," "dentist," and "STEM" were used.

Measures

Doll careers were identified by visually analyzing the clothing, accessories, and packaging of Barbie and comparison brand dolls. Clothing, accessories, and hair were visually analyzed to determine if dolls met laboratory and clinical safety standards. Data within this study, which were collected and analyzed by a single author, are represented by simple counts and proportions. These counts and proportions were used to analyze the kinds of jobs the included dolls had, the demographics of the dolls, their clothes and accessories, and their hairstyles.

Participants

Participants consisted of Barbie brand and non-Barbie brand dolls depicted as having medical and scientific careers. Dolls were eligible to be analyzed in this study if they were: an official Mattel Barbie brand doll; were mass produced (ie, not one-of-a-kind or custom made); were depicted working as a laboratory scientist, science educator, medical doctor, dentist, nurse, or paramedic. Comparator dolls (ie, non-Barbie brand dolls) that depicted one of the aforementioned careers were also eligible for analysis. Dolls were ineligible for this analysis if they were: a Barbie signature or other special edition Barbie doll aimed exclusively at collectors; modelled on a real person (eg, Florence Nightingale) or popular culture character (eg, Julia Baker and Dana Scully); or depicted a job related to science and medicine that was outside of the eligibility criteria (eg, veterinarian, marine biologist, and paleontologist dolls), unless they were prespecified comparison dolls (ie, specific engineer and MRI technician dolls). To further ensure the focus remained on playline dolls, I excluded playsets and fashion packs that did not include dolls.

Definition of laboratory and clinical safety guidelines

The laboratory and clinical safety guidelines by which all analyzed dolls were judged was based on guidance released by Indiana University, a distinguished research university that all educational facilities should proudly model themselves after. University Policies PS-EHS-02 require that all students and employees wear closed-toed shoes and full-length pants/trousers and skirts

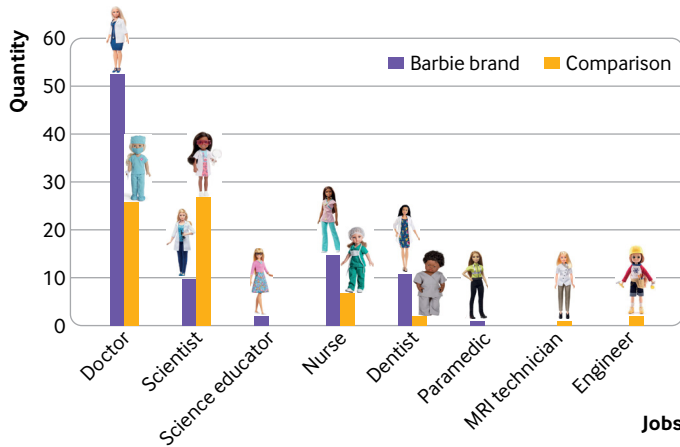


Fig 1 | Jobs of Barbie brand and comparison dolls. The Barbie brand doll group (n=92) was mostly doctors (58%, n=53/92). The comparison doll group (n=65) had more scientists (41%, n=27/65) than did the Barbie brand doll group

when in a laboratory setting. Loose hair and clothing must be tied back. Laboratory coats, disposable gloves, and safety goggles or glasses are required within many Indiana University laboratories, especially laboratories where dangerous chemicals such as explosives, oxidizers, and organic peroxides are used.^{16 17} The Indiana University laboratory safety and chemical hygiene plan further requires that laboratory coats be made entirely of cotton or be flame-resistant, as needed for each laboratory. Whenever possible, clothing should minimize skin exposure. Laboratory coats and other personal protective equipment should also be long enough to prevent contact with the skin without being overly long or baggy. Shoes should minimize an individual's risk of slipping.¹⁷

Thus, a scientist doll will be viewed as adhering to these guidelines if it wears a wrist length laboratory coat, pants or skirt that covers the entirety of the legs, shoes that cover the entirety of the foot, safety goggles or glasses, and gloves. Hair must be short or tied back.

These same guidelines, while designed for laboratory work, also largely apply within clinical

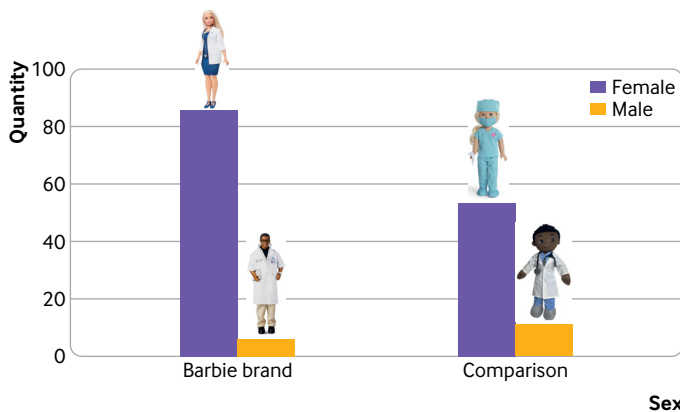


Fig 2 | Sex of Barbie brand and comparison dolls. Barbie brand dolls (n=92) were almost all female (93%, n=86/92). The comparison dolls (n=65) were 83% female (n=54/65) and 17% (n=11/65) were male

settings, and were used to judge all analyzed medical professional dolls. Medical professionals are regularly in contact with patients who may be infectious or may otherwise be a potential harm to their health. As such, medical professional dolls were considered adherent to guidelines if they wore wrist length laboratory coats, fully covering pants or skirts, and gloves, as well as had short or tied back hair. Although these guidelines may seem overly stringent for a medical setting, numerous analyzed medical professional dolls were shown working with children, indicating that medical professional dolls should minimize skin and hair exposure to protect themselves from the grubby handed germ factories that they treat.

Statistical analysis

No statistical software was used for this analysis. All statistics were calculated by dividing a subset of dolls against total dolls. All information about the dolls, including collected demographics and other statistical information, was reviewed, and re-calculated by the author three times to ensure accuracy.

Patient and public involvement

Patients and the public were not involved or consulted in any way during this research.

Results

92 Barbie dolls and 65 non-Barbie brand comparison dolls were analyzed. Figures 1-4 contain the analyzed dolls' professional, sex, ethnic, and age demographics.

Objective 1: the types of scientist and medical professional dolls

Barbie brand medical professional dolls (n=80) were depicted overwhelmingly as doctors (66%, n=53/80), with smaller numbers of Barbie brand dolls being shown working as nurses (19%, n=15/80), dentists (14%, n=11/80), and paramedics (1%, n=1/80) (fig 1). Medical professional Barbie dolls worked with children in 53 (66%) of 80 dolls. Only one Barbie brand doctor doll (1%) of 80 medical dolls was directly depicted working with adult patients. All male Barbie brand dolls (ie, Ken) analyzed (n=6) were doctors (83%, n=5/6), three of which were shown working with children, and dentists (17%, n=1/6). Of the 52 Barbie brand doctor dolls, 51 (98%) came with stethoscopes, while items such as face masks (4%, n=2) and axillary crutches 2% (n=1) were much rarer. Box 1 below depicts the various medical accessories that came with doctor Barbie, Ken, or Chelsea dolls. These items largely correlate to non-specialized care. Other than three ophthalmologist dolls (two (66%) of which were pediatric ophthalmologists), all Barbie brand doctor dolls appeared to have either no specialization or were pediatricians with no apparent subspecialization.

Like doctor dolls, most of the 15 nurse Barbie dolls came with stethoscopes (60%, n=9). Only two (13%, n=2) nurse dolls were depicted working with children, while another two (13%, n=2) worked with adults; more specifically, one of them, civil war nurse

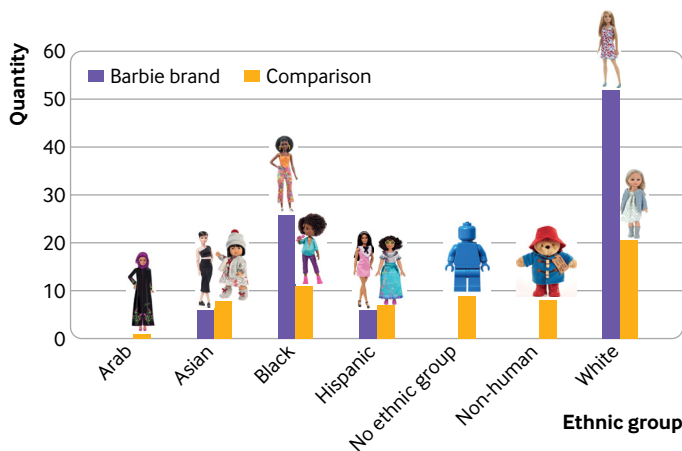


Fig 3 | Ethnic groups of Barbie brand and comparison dolls. Over half of Barbie brand dolls (n=92) were white (59%, n=54/92). Among the comparison doll group (n=65), only 32% (n=21/65) of the comparison dolls were white, with more than a quarter of comparison dolls being non-human or being human but having no ethnic group (26%, n=17/65)

Barbie, was a battlefield nurse. The remaining 11 (74%) of 15 nurse Barbie dolls were not depicted working with any specific kind of patient and appeared to have no specialization. The 11 dentist Barbie brand dolls, which all came with laboratory coats and toothbrush and toothpaste accessories, were either pediatric dentists (91%, n=10) or had no specialty (9%, n=1).

Twelve scientist Barbie dolls were depicted as either bench scientists in the laboratory (83%, n=10) or science educators (17%, n=2). All 12 scientist dolls were women. Box 2 lists the different types of doll sized science accessories that came with the Barbie dolls. Eleven (92%) of 12 Barbie brand scientist dolls came with a microscope accessory, whereas items such as the alcohol burner (8%, n=1/12) were included with far fewer dolls. These items indicate that the scientist Barbie dolls, whether bench researchers or educators, are largely chemists and biologists. A full list of Barbie brand and

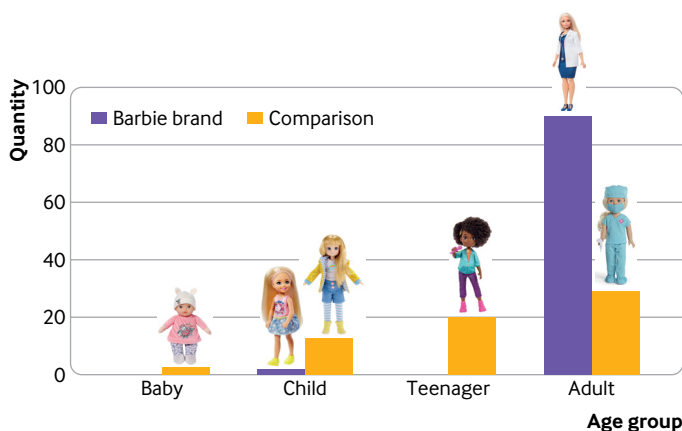


Fig 4 | Ages of Barbie brand and comparison dolls. All Barbie brand dolls (n=92) were either adults (98%, n=90/92) or children (2%, n=2/92). Alongside adults (45%, n=29/65) and children (20%, n=13/65), the comparison doll group (n=65) included baby (5%, n=3/65) and teenage (31%, n=20/65) career dolls

comparison professional dolls analyzed is presented in supplementary tables A and B.¹⁵⁻¹⁵⁰

Two of the scientist Barbie dolls came with Barbie branded science, technology, engineering, and math (STEM) kits. The only difference between the two kits was the character doll (ie, Barbie or Nikki) that came with each kit. The Barbie STEM kit featured simple experiments that crossed multiple scientific disciplines including chemistry, biology, and engineering. Using the kit's storybook manual, children could use Lego-like blocks to build a doll sized shoe rack, spinning dress rack, rotating closet, greenhouse, washing machine, and dress design platform. Chromatography and photosynthesis principles could be used to help design doll dresses.

Most of the 65 comparison dolls were scientists (41%, n=27) and doctors (40%, n=26), with smaller numbers of nurses (11%, n=7), dentists (3%, n=2), and engineers (3%, n=2). One doll was an MRI technician doll (2%) (Fig 1). The type of accessories that came with comparison dolls depended on the brand of doll analyzed and what profession each doll depicted (Supplementary Table B). Demographics for the comparison dolls can be found in (Fig 2-4). Overall, the comparison dolls were still mostly female but represented more ethnic and age groups than the Barbie brand doll group did. Non-Barbie brand dolls also represented more medical specialties than the Barbie brand dolls, which is not surprising because the G.I. Joe team needs field army doctors rather than generalized pediatricians. Eight (38%) of the 21 adult medical professional dolls in the comparison group were depicted working with children. As more than half (53%, n=9) of the 16 baby and child dolls were play doctors and nurses (eg, Doc McStuffins) rather than professionals, some of the medical paraphernalia represented were (naturally) inauthentic. Both dentist dolls analyzed were female pediatric dentists. None of the seven comparator nurse dolls had a specialty. The two engineer dolls analyzed consisted of a professional roboticist and a child (non-professional) engineer.

Barbie has largely monopolized the toy market for adult scientist dolls because only one (4%) of the 27 scientist comparison dolls was an adult. The rest of the scientist dolls analyzed consisted of a mix of high school students in science class (26%, n=7), teenage secret agents (48%, n=13), and science-loving tweens (22%, n=6). All comparison doll characters depicted a wide range of scientific interests and specialties, from engineering to biology and astronomy. This diversity is best exemplified through the Project Mc² dolls (n=13), which depict teenage scientist super spies who each specialize in different scientific fields, from chemistry to engineering. All Project Mc² dolls came with experiments that children could perform at home. Despite the characters' range of scientific interests, the experiments that came with the Project Mc² dolls were only based on chemistry and engineering. All 27 comparison scientist dolls analyzed were female.

Box 1: Medical paraphernalia that came with different Barbie brand doctor dolls

- Axillary crutch
- Bandage
- Beeper
- Birth certificate
- Blood pressure cuff
- Blood pressure gauge
- Clipboard
- Direct ophthalmoscope
- Doctor's bag
- Doctor of medicine degree
- Exam table
- Eye chart
- Face mask
- Head mirror
- Landline phone
- Medicine bottle
- Microscope
- Orthopedic cast
- Otoscope
- Patient chart
- Phoropter
- Reflex hammer
- Retinoscope
- Scale
- Skeletal system diagram
- Stethoscope
- Syringe
- Tongue depressor
- Tongue thermometer
- X ray diagrams

Objective 2: analyzed dolls and clinical and laboratory safety standards

Female scientist and doctor Barbie dolls mostly wore clothing, accessories, and hairstyles that directly hindered their safety and interfered with their job performances. Of the 86 female medical professional and scientist Barbie brand dolls, only 25 (29%) had their legs fully covered. Of the 71 medical professional and scientist Barbie brand dolls that came with laboratory coats, half (51%, n=36) did not have sleeves that came down to the wrists. All 12 scientist Barbie brand dolls came with safety glasses and 10 (83%) came with laboratory coats. Only one of the 80

Box 2: Laboratory paraphernalia included with Barbie laboratory scientist and science educator dolls

- Alcohol burner
- Beaker
- Bunsen burner
- Electronic scale
- Erlenmeyer flask
- Laptop
- Microscope
- Round bottomed flask
- Rubber tubing
- Test tube

(1%) medical professional Barbie brand dolls came with a face mask, and none of 92 medical professional or scientist Barbie brand dolls included gloves. Figure 5 summarizes the hairstyles of Barbie brand female medical professional and scientist dolls (n=86). More than two thirds of female dolls wore loose hair (70%, n=60), even in settings where this would be discouraged or actively prohibited. Similarly, figure 6 depicts the shoe styles worn by all the 86 female Barbie brand dolls, of which more than half (57%, n=49) wore high heeled shoes. Figure 7 depicts the pant/trouser and skirt lengths of the 86 female medical professional and scientist Barbie brand dolls, of which only 29% (n=25) had their legs fully covered. Of the 15 nurse Barbie dolls, more recent dolls tended to wear scrubs (53%, n=8), with older dolls sticking to light coloured dresses and nurse's caps (20%, n=3). These changes in dress likely reflect changing ideas as to what nurses are expected to wear. All six medical professional Ken dolls had short hair and wore full length pants and flat shoes with full coverage, although only three (50%) wore wrist length laboratory coats.

The non-Barbie brand comparison dolls were a heterogeneous group (Supplementary Table B). The three baby dolls would never meet clinical and laboratory safety guidelines by virtue of their age. All nine of the various child-aged play doctor and nurse dolls do not meet clinical dress codes in some manner, either through loose hair, too short laboratory coats, and/or too short pants and skirts. They should learn proper medical and laboratory safety standards by the time they are old enough to enrol in university. The 13 Project Mc² dolls all wore clothes that should never be worn within a laboratory setting, including items such as crop top shirts, high heeled shoes, and open toed sandals. All Project Mc² dolls also came with loose hair. These errors can be somewhat forgiven because the dolls actively depict the girls outside of the laboratory doing undercover work. The Monster High dolls do not have this excuse. Seven (88%) of eight of the dolls are actively depicted within a classroom laboratory setting despite six (86%) of seven of the (all-female) dolls based in the laboratory having loose hair and none of these dolls having clothing that fully covers their legs. Six (86%) of the seven female dolls also wear high heels. The token male Monster High comparison doll, Hexiciah Steam, may have fully covered legs, but shorts with knee high socks are not considered a laboratory safe substitute for ankle length pants.¹⁶¹⁷

Although most comparison dolls had notable clinical or laboratory safety errors, some doll brands were much more accurate. Ten (91%) of 11 Lego figures had short or tied back hair and all 11 wore clothing safe for the clinic and laboratory. Similarly, the Playmobil doctors and Beverly Hills Doll Collection doctor and nurse dolls had short or tied back hair and wore fully covering clothing safe for the clinic and laboratory. The G.I. Joe Doc and Scalpel dolls both easily meet clinical and laboratory safety standards while still being prepared to enter the battlefield. Although not actively being depicted doing anything science related,

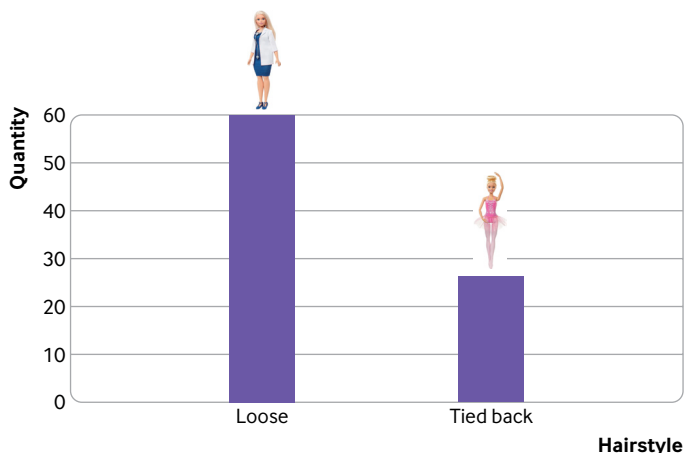


Fig 5 | Hairstyles of Barbie brand medical professional and scientist dolls. Most female medical professional and scientist Barbie dolls (n=86) had loose hair (70%, n=60/86). No female Barbie brand career doll analyzed had short hair

the scientist Shuri doll analyzed had short hair and long clothing that would easily be approved for use in a laboratory setting, provided that her clothes are not made of flammable fabrics and that she removed her Kimoyo bead bracelet.

Other data

More than half of all the 92 Barbie brand dolls analyzed were white (59%, n=52), with black dolls making up a smaller percentage of all professional dolls (28%, n=26) (fig 3). Hispanic and Asian dolls each accounted for 6% (n=6) of all analyzed dolls. All six Asian dolls were East Asian. As a result of the heterogeneity of the comparison doll brands and their respective toy manufacturers, direct comparisons of the ethnic group demographics between the Barbie and non-Barbie doll brands cannot be made. The comparison dolls did contain Arab dolls and dolls without races, which the Barbie brand dolls did not include. The comparison dolls themselves were more diverse in terms of manufacturer because Barbie is an American-owned

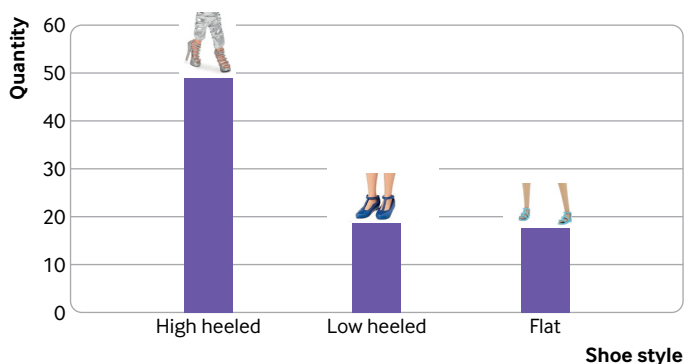


Fig 6 | Shoe styles of medical professional and scientist Barbie brand dolls. Of the female medical professional and scientist Barbie brand dolls (n=86), only 21% (n=18/86) wore flat shoes

doll brand; the comparison dolls included dolls from Danish, German, Korean, and Syrian manufacturers .

Besides various dolls wearing eyeglasses, no Barbie brand dolls had a physical disability and worked as a medical professional and laboratory scientist. The comparison dolls only had one example of a physically disabled doll, that being the Monster High Hexiciah Steam doll, which had a prosthetic arm.

Discussion

This study analyzed Barbie brand medical and science themed career dolls to identify what kind of careers, including specializations, each doll held and determined whether dolls met medical and scientific professional safety standards by analyzing their respective hairstyles, outfits, and accessories. Non-Barbie brand dolls were analyzed along these same parameters to understand how they portrayed medicine and science and to determine how these representations compared with and differed from Barbie brand dolls. Demographic information was collected for all analyzed dolls. Most Barbie brand career dolls were physicians, with nurses comprising the second largest professional demographic. The Barbie brand dolls were overwhelmingly depicted as female, white, and adult aged. No Barbie brand career doll was depicted as having a visible disability. No Barbie brand doll fully met professional safety standards for their respective fields, with some being at serious risk of experiencing a workplace related injury or infection due to a scarcity of personal protective equipment. Comparison career dolls were equally as likely to be depicted as physicians and laboratory scientists. Compared with Barbie brand dolls, comparison career dolls came in a wider range of ethnic groups and ages, depicted more scientific subspecialties, and even included a single visibly disabled engineer doll. Although a minority, male dolls made up a larger proportion of total dolls within the comparison career dolls group than in the Barbie brand dolls group. However, due to the heterogeneity of the comparison dolls, exact demographic comparisons could not be made. Most comparison career dolls also did not meet professional safety standards for their respective fields. This study fills a questionably important gap in the scientific literature and asks questions that few other scientists have entertained, let alone lost sleep over.

Medical professional dolls’ specialties (or lack thereof)

Pediatricians and pediatric dentists were over-represented among the doctor and dentist Barbie dolls. None of the pediatrician and pediatric dentist dolls appeared to have clinical sub-specialties except for the pediatric ophthalmologist dolls. Only two nurse dolls were depicted treating children, and only three were depicted having a specialty despite nursing being a highly specialized field. All the child or baby dolls treated by medical professional Barbie dolls appeared to be able bodied, indicating that said medical professional dolls did not treat complex

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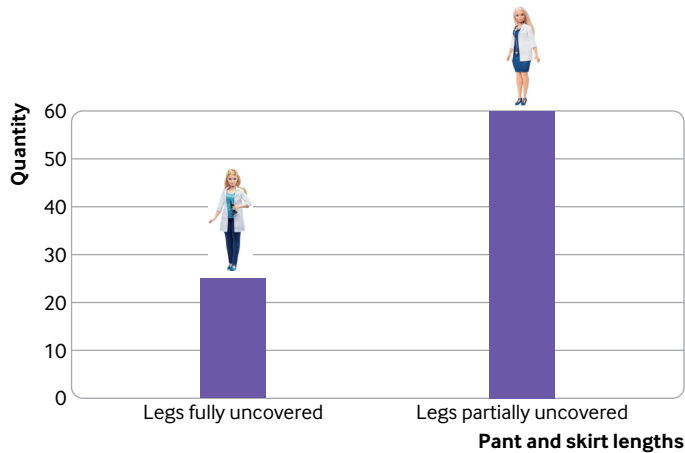


Fig 7 | Pant (trouser) and skirt lengths of female Barbie brand medical professional and scientist dolls. 71% (n=61/86) of all female medical professional and scientist dolls (n=86) did not have their legs fully covered, even in environments where having skin exposed is dangerous, such as wet laboratories

illnesses or injuries. Among Barbie dolls, almost every doctor and all dentists wore laboratory coats. Although laboratory coats have become synonymous with physicians,¹⁵¹ whether future pediatrician (and other pediatric specialty) dolls should continue wearing them is debatable because many pediatricians have begun foregoing them altogether to help alleviate their young patients' medical anxieties.¹⁵² Only two nurses and one doctor Barbie doll was depicted treating adult patients. The comparison dolls only had a handful of non-pediatric specialists, all of which were from the G.I. Joe brand. Doc is a battlefield emergency medicine specialist and Scalpel is a mercenary surgeon. Although fewer pediatric specialist dolls were in the comparison group than in the Barbie brand group, all pediatrician and pediatric dentist comparison dolls were female. Even while working as physicians and dentists, two traditionally male dominated careers, women are still considered to be the protectors and caretakers of children. Dr Ken dolls were only depicted working with boys or children with no specified sex; only female medical professional Barbies were ever shown treating girls.

A large focus by children's toy companies on treating children is understandable. Few children long to become geriatricians. Yet, Mattel has marketed Barbie as a trailblazer for decades. With women now compromising 65% of American pediatrician roles¹⁵³ and most pediatric dentists,¹⁵⁴ Barbie will have to set her sights on male dominated specialties if she wants to keep breaking glass ceilings. This statement is not meant to diminish the value of pediatrician dolls. Role playing a doctor or dentist's appointment can help children alleviate fears they have about their own appointments.^{155 156} In much the same manner, Mattel could benefit children by depicting medical professional dolls working with adult patients. Children of parents and other carers with serious medical conditions are often intimately familiar with medical appointments, staff, and treatment, even if they themselves are not the patients. Role playing a

doctor, nurse, or dentist treating a fellow adult patient could likely help them to better grasp what a guardian is facing and address any fears they might have.

Scientific specialties of laboratory scientist dolls

Scientist Barbie dolls often came with biology and chemistry related laboratory equipment. When asked to draw a scientist, children overwhelmingly create images of chemists and biologists. These images usually contain drawings of items such as test tubes, microscopes, and laboratory coats.¹⁵⁷ Other than all the dolls being female, the scientist Barbie dolls did not greatly differ from children's general perceptions of scientists.^{157 158} Although not analyzed in this study, dolls such as the astronaut, paleontologist, and marine biologist Barbie show that Mattel offers products that allow children to expand their idea of what a scientist looks like and does. The American Girl doll characters (which are created and owned by Mattel) analyzed within the comparison were interested in astronomy, aerospace engineering, veterinary medicine, and wildlife biology. Mattel should continue to diversify the kinds of scientists its dolls depict across its various doll brands. From epidemiologist to crime scene investigator and statistical analyst, scientists wear many different titles. Recent box office movie trends suggest a nuclear physicist Ken doll could be particularly profitable.

Medical professional dolls' adherence to clinical safety standards

The female medical professional Barbie dolls were mostly depicted as having loose hair and wearing high heeled shoes and pants or skirts that ended above their ankles. As a safety precaution, many hospital and clinical dress codes would likely require doctor, nurse, dentist, and paramedic Barbie to tie her hair back, wear slip-proof and full coverage footwear, and cover her legs. This dress code is especially true depending on her specialty and what kinds of patients she works with. The high number of female doctor, nurse, and dentist dolls, in both Barbie and comparison groups, wearing high heeled shoes was particularly concerning. As many female medical professionals can attest, this footwear is not comfortable for a long day on rounds. Heels also put Dr Barbie and her comparison coworkers Drs Fulla and Steffie Love at greater risk of injuring themselves and needing their own medical care.^{159 160} By contrast, the female Lego, Playmobil, and Beverly Hills Doll Collection doctor and nurse dolls were much more clinically accurate.

The difference between what doll and real doctors wear is visualized in the live action *Barbie* movie itself. Although the multiple actors depicting doctor dolls within the movie are often seen with loose hair and high heels, the real doctor that Ken meets within the human world has short hair and wears scrubs. Although less visually vibrant, this real doctor's attire would not interfere with her work. This is not to imply that Dr Barbie, whether she is on toy shelves or the silver screen, should be changed beyond recognition. She

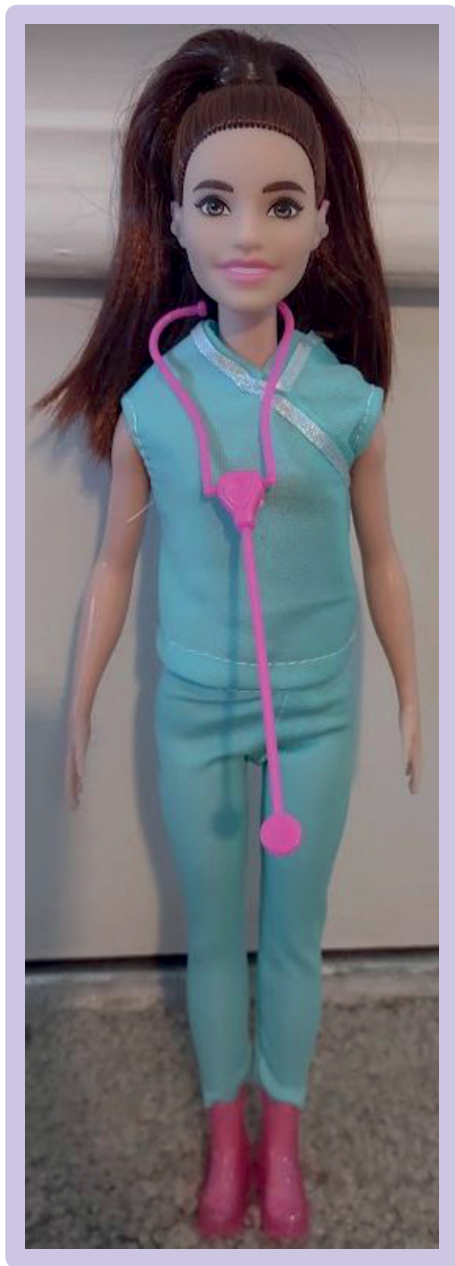


Fig 8 | A disabled pulmonologist doll. The author created a hard of hearing doctor Barbie doll using a Fashionista #188 doll and a Dollar Tree medical fashion set. With her hair tied back, slip-resistant pink boots, scrub set, and digital stethoscope designed for people with hearing loss, Dr Barbie is ready to treat patients. Her wrist length lab coat is not pictured. Dr Barbie obtained her BS in chemistry from Handler University before obtaining a combined MD and PhD from the Indiana University School of Medicine, where her doctoral thesis focused on epidemiologically modeling estimated incidence rates of lung cancer in young adults by the year 2040. She returned to Handler University to undergo a pulmonology fellowship and is now a staff member of Handler University Hospital's pulmonology department where she specializes in treating patients with asthma-COPD overlap syndrome and patients with combined COPD and lung cancer. Photo provided by author. COPD=chronic obstructive pulmonary disease

can still wear a pink laboratory coat, provided it goes down to her wrists; Dr Barbie should be fashionable but also safe. Although Mattel's main motive will always be profit, Gerwig's *Barbie* movie, and Mattel's growingly diverse Barbie doll lines, show that Mattel is aware of and respondent to criticisms about the brand. Indeed,

Barbie ticket and doll sales show that responding to audience and consumers' criticisms can itself be profitable, indicating that revised medical and scientific career dolls could prove beneficial for Mattel's sales.

Laboratory scientist dolls' adherence to laboratory safety standards

In a world where many girls struggle to picture women as scientists,¹⁵⁸ Mattel depicting all the scientist dolls as female is commendable. Yet, the dolls themselves misrepresent laboratory work. If these Barbies were real, all the academic achievements in the world would not allow them inside a single medical research or educational laboratory because they all, in some form, fail to follow basic laboratory safety protocol. All scientist Barbie dolls had loose hair. Long hair must be tied back in the laboratory to prevent it from getting caught in experiments and machinery.¹⁶¹ While most scientist Barbie dolls came with laboratory coats, only one doll wore a laboratory coat that came down to her wrists. Wrist length laboratory coats are some of the most basic forms of personal protective equipment and are required in many laboratories where scientists work with chemical and biological samples.¹⁶² Similarly, only one Barbie scientist doll wore shoes that fully covered her toes and feet, and many wore high heeled shoes. Laboratories require slip resistant shoes that completely cover the toes and feet to minimize the potential for laboratory related injuries.^{163 164} Multiple scientist Barbie dolls wore jewellery despite jewellery being prohibited in chemistry laboratories where it could retain chemicals.¹⁶⁵ No dolls wore or came with disposable gloves, which, when properly fitted, can prevent chemical and biohazard exposure.^{166 167} Of the comparison scientist dolls, only the Shuri doll wore laboratory safe clothing. All other scientist dolls, especially the Monster High and Project Mc² dolls, had loose hair and clothing that would have hindered or actively endangered them in the laboratory. In the future, Mattel and other toy companies should prioritize creating dolls with short or pulled back hair; ankle length pants and skirts; closed toed, flat shoes; faux disposable gloves; and wrist length laboratory coats. Personal protective equipment may not be trendy, but no woman wants to be "drop dead gorgeous" because of preventable causes.

The fact that the Barbie and Nikki dolls included with the STEM kits did not follow laboratory safety procedures was particularly alarming due to their work with machinery. Although the STEM kit's machinery is composed of Lego-style plastic blocks and gears, real scientists have died when loose hair was caught in laboratory machinery.¹⁶¹ Even non-fatal laboratory injuries, which include such unpleasant events as chemical burns and laboratory borne infections,^{168 169} can lead to serious injury and disability. By failing to depict Barbie and Nikki following proper laboratory safety protocols, Mattel made the characters seem needlessly irresponsible. The scientist Chelsea doll was similarly concerning because she failed not only to tie back her hair and wear a proper laboratory

coat and pants, but her corresponding accessories included glassware and an alcohol burner, laboratory paraphernalia that no child should use without trained adult supervision.

It is worth noting that Barbie has only recently begun performing laboratory work. Doctor Barbie dolls were first released in 1973 (happy 50th anniversary, Dr Barbie!), while laboratory scientist Barbie dolls debuted in 2015. Yet, despite only relatively recently finding her footing within Barbie's extensive career canon, laboratory scientist Barbie appears to be here to stay based on the numerous variations of her that Mattel has released. With a few tweaks, laboratory scientist Barbie has the chance to inspire many girls to become tomorrow's safety-oriented bench scientists.

Future opportunities for doll related diversity

The existence of Barbie's friends Ella (a cancer survivor) and Becky (a wheelchair user), as well as the growingly diverse Barbie Fashionistas line (which includes unnamed dolls with hearing aids, Down Syndrome, alopecia areata, prosthetic limbs, and vitiligo) begs the question of whom they receive treatment from. Their existence would imply that oncologist, orthopedic, audiologist, dermatologist, cardiologist, and neurosurgeon Barbies exist, but Doctor Barbie and Ken dolls have only been depicted as generic or pediatric physicians, dentists, nurses, and ophthalmologists. Specialist dolls would provide all children with a richer view of the medical field and further highlight children's future career possibilities. Children with disabilities and chronic illnesses would particularly benefit from specialist dolls because they could not only role play their appointments but also have a tangible method to describe and show their treatment to their able-bodied peers. Many parents would likely find specialist dolls useful when explaining the concepts of illness and disability to their children.¹⁷⁰

Mattel (as well as other toy manufacturers) would benefit from diversifying the ethnic groups and abilities of their scientist and doctor dolls. Despite people of Asian descent comprising over 9% of all scientists and 20% of all physicians in the United States,^{153 171} very few Barbie career dolls were Asian. Hispanic people account for 8% of all scientists and 7% of all physicians within the United States,^{153 172} yet they account for few of the Barbie brand and STEM and medicine themed dolls. The number of Asian and Hispanic dolls should be increased to better match, if not exceed, the rates of Asian and Hispanic medical professionals and scientists within the United States. Because medicine and science should be open to everyone, Mattel should also consider releasing more black medical professional and scientist dolls, as well as introduce medical professional and scientist dolls with disabilities like they have disabled dolls with other professions. Like Barbie herself, the possibilities for these dolls are endless, from a physical therapist who uses a wheelchair to a dentist with a cochlear implant. An example of a disabled medical professional Barbie

doll, created by the author, can be seen in Figure 8. These suggestions, while primarily aimed at Mattel, should be heeded by other toy companies.

Doll sales are cyclical, with many dolls only being sold for one to a handful of seasons before being shelved by manufacturers. Unless specific dolls are reproduced, often for collectors, then an exact doll may never be released again. Doll manufacturers may, however, make similar dolls following the same idea or theme. For example, while the 1988 Doctor Barbie has never been reproduced, many other Barbie brand doctor dolls have been made. Mattel and other doll brands can, and often do, create improved versions of dolls, whether by direct reproductions or variations of previous merchandise. The ever-changing availability of dolls also makes the possibility for better, more diverse, and more accurate medical professional and scientist dolls more likely.

Strengths and limitations of study

Although I made every effort to include as many medical professional and laboratory scientist dolls as I could in this study, the combined outputs of large and small toy companies is so vast that some dolls may have been overlooked. Based on the relative homogeneity of the medical professional and scientist Barbie dolls that were analyzed in this study, I estimate that any products that I potentially missed would not differ greatly from those that I analyzed. The comparison dolls most certainly do not depict every medical and scientist doll ever created. Beyond G.I. Joe, many other dolls are largely marketed towards boys (otherwise known as action figures) that feature medical professionals and doctors. Future research could analyze these dolls to understand their medical and scientific specialties and adherence to clinical and laboratory safety procedures.

The dolls within the Barbie brand group were largely homogenous whereas the comparison doll group was heterogeneous. Had only similarly sized fashion dolls been included within the comparison doll group, then the comparison doll group would have been much smaller. The kind of doll analyzed had to be expanded beyond the roughly 29 cm fashion dolls to get a similar participant size within the comparison doll group. The Barbie brand group has a paramedic doll that the comparison group does not, while the comparison group has an MRI technician doll which the Barbie brand group lacks. The comparison doll group has engineer dolls while the Barbie brand group only has doll playsets that incorporate engineering themes. Although exact comparisons cannot be made between the two groups, enough similarities are available for patterns to be identified between the two doll groups.

No in-depth statistical analysis was used, and all research was identified, gathered, and analyzed by a single author. Based upon the methods by which dolls were identified and analyzed, as well as the robust supplementary materials, other researchers can easily access information about each doll and run their own analyses to attempt to reproduce this study's data.

Comparison to previous studies

This study is the first to analyze and critique medical professional and scientist Barbie dolls through the eyes of a medical researcher. All previous studies about medical professional and scientist Barbie dolls have been sociological in nature and studied how these dolls affect children's views of medicine and science and their perceived ability to pursue them as careers.¹⁷³

¹⁷⁴ Although the aims of this study differ from previous research, sociologists could build on this study's results by studying how Barbie and other doll brands' medical professional and laboratory scientist dolls affect children's understandings of various medical and scientific fields and the clinical and laboratory safety procedures associated with them.

Conclusion and implications

Barbie has a commendable resume that spans various careers, many of them male dominated. To prevent Barbie from being barred from her place of work, future dolls should be equipped with the proper personal protective equipment needed to safely perform laboratory and medical work. Additionally, Dr Barbie should consider expanding her scientific and medical careers into subfields where women remain a minority, for young girls' sake as much as her own.

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Ethical approval: Institutional review board review and approval was not required for this study because all participants were inanimate objects. I attest that we have obtained appropriate permissions and paid any required fees for use of copyright protected materials.

Data sharing: Original datasets can be obtained by contacting the author. Additional data will be provided by the author to individual readers as requested.

The author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for recruitment, design, or implementation of the study. No patients were asked to advise on interpretation or writing up of results. There are no plans to disseminate the results of the research to study participants or the relevant patient community.

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Web appendix: Analyzed Barbie brand dolls
Web appendix: Analyzed comparison dolls