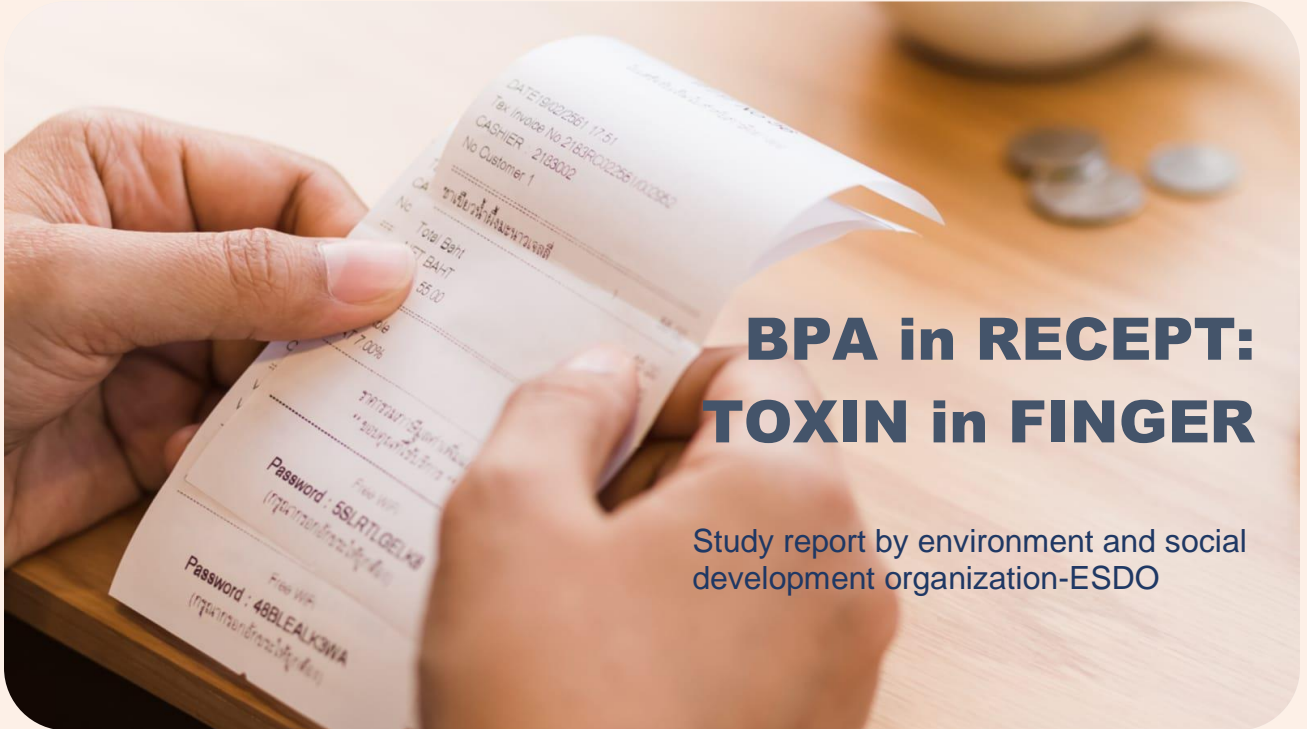




toxins



BPA in RECEIPT: TOXIN in FINGER

Study report by environment and social development organization-ESDO



Title: BPA in RECEIPT: TOXIN in FINGER

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Overall supervision

Study team led by Dr. Shahriar Hossain, Supervation by Siddika Sultana, Assist by Sarah Jabeen Kristy.

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Study Team Leader

Shahriar Hossain, Ph.D.

Coordination and Supervision

Siddika Sultana

Technical Assistance

Prof. Abu Jafar Mahmood and Prof. Md. Abul Hashem

Editorial Team

Sarah Jabeen Kristy, Hridita Ferdous

Research Associate

Fahmida Sarker, Tanvir Hasnin

Support Team

Golam Rabbani, Samina Khondaker, Sharmin Jahan, Khalilur Rahman

Cover Design & Illustration

Shahriar Hossain, Mamun Ul Hasan

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Contact

Tel: +880-2-55008178, +880-2-8100527

E-mail: info@esdo.org, www.esdo.org

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Abbreviations

- ATM (Automated Teller Machine)
- BPA (Bisphenol A)
- CAGR (Compound Annual Growth Rate)
- EDC (Endocrine Disruptive Chemical)
- ESDO (Environment and Social Development Organization)
- PC (Polycarbonate)
- PCOS (Polycystic ovary syndrome)

Executive Summary

High levels of bisphenol A (BPA) in thermal paper cash register receipts has become a slow poison towards human health and environment. If there is one thing people probably touch every day, over and over again, it is cash register receipts. It is everywhere in wallet, pocket, or the bottom of purse as well. Recent researched proved that, these innocent-looking piece of papers contain high rate of bisphenol A (BPA) and this chemical absorbed in real quick to human body and poses high risks of health gradually. As there is a cost to health, whenever it involves spending money at a store, the cost may be more than just the amount shown on the cash register receipt.

Bisphenol A or BPA, is a precariously destructive chemical produced in large quantities for use primarily in the production of polycarbonate plastics and epoxy resin. It is a growth inhibitor, reprotoxic and endocrine disruptive chemical (EDC) which is damaging both for the environment and human health. BPA has an association with an increased risk for obesity, diabetes, high blood pressure, and cardiovascular disease. Pregnant women, infants and young children are at the greatest risk in various ways. BPA is broadly used as a plasticizer that is bound in polymers to make plastic bottles and food can liners and on thermal imaging paper used to print credit-card and cash register receipts, point-of-sale receipts, ATM receipts, prescription labels, airline tickets and other machine-generated receipts. BPA exposure have linked to an increased risk for premature death. Scientists have analyzed that people with the highest levels of BPA in their urine had a 51% higher risk of dying during that period, primarily from heart disease, compared with people who had the lowest levels of BPA .

Studies have also shown that infants born to mothers exposed to BPA weigh up to half a pound less, on average, than infants born to unexposed mothers .

This specific study aims to give an brief idea about harmful health effects of BPA in thermal papers with data analysis and also current situation analysis on awareness level of people on tis matter. Through this study Environment and Social Development Organization-ESDO hopes that it will highlight the urgent need for research for BPA- free cash receipts in Bangladesh and push the government to initiate further research and regulatory measures on BPA in thermal papers and other products.

This report included information gathered from physical surveys of retailers and consumers and laboratory assessments of cash receipts/ thermal papers. To assess the situation and public perception on Bisphenol-A (BPA) in thermal papers used in popular outlets in Bangladesh. A baseline survey had been conducted physically through questionnaires and carried out from February 2019 to January 2020 on total 1350 people (Consumer and retailers). Besides, more than 40 cash receipts have been collected from local shops (Fast food shop, restaurants, pharmacy etc.) and ATM booths of the surveyed areas. Surveyed population recognizes the thermal papers as slips but unfortunately, 0% surveyed population unknown or unaware of BPA-containing thermal paper and its harmful effects. Laboratory tests of thermal papers indicated the presence of BPA in quantities ranging from 10 – 53 $\mu\text{g}/\text{cm}^2$. All the receipt samples have ***a higher percentage of BPA (0.8% - 3.7% by weight) than the EU permissible limit (0.02% by weight)*** which shows us the severity of the situation.

Several countries have set limits of BPA exposure and adopted legislation against the use of BPA in various products. But Bangladesh does not yet have specific regulations for BPA in thermal paper or other products. As a developing country, Bangladesh has yet to realize the detrimental effects of BPA and put it under legislation and research.

As, BPA is one of the major concerning chemicals nowadays which affects infants to adults and can be found everywhere in regular life, before the situation gets worse the government of Bangladesh needs to regulate BPA in thermal papers very strictly. With all limitations, ESDO completed this important study as a startup. In this study, although this few samples testing is not sufficient for drawing conclusions about the toxicity of thermal paper, but this study already found the presence of a high level of BPA in thermal paper from collected samples which is very distressing. Nevertheless, this study finding is good enough to give maximum attention and emphasis to action immediately to do borad research and policy advocacy to implement regulation to ban thermal paper cash receipts for greater good.

Introduction

Bisphenol A or BPA, is a precariously destructive chemical produced in large quantities for use primarily in the production of polycarbonate plastics and epoxy resin.. It is a growth inhibitor, reprotoxic and endocrine disruptive chemical (EDC) which is damaging both for the environment and human health. BPA is generally employed for the production of epoxy resins and polycarbonate (PC) plastics, is utilized in various food and drink packaging, baby bottles and dental sealants which is also a strong endocrine disruptor and also leads to carcinogenesis as well¹. Several Taxonomy studies have already shown that BPA has estrogen activity which can disrupt physiological activities in plants, animals and humans^{2,3}. As BPA is an endocrine disruptive chemical, they act like a hormone in the body, disrupting normal hormone levels and development in fetuses, babies, and children. It also disturbs the development and function of the mammary glands⁴. BPA exposure has also proved to accelerate one of the most common gynecological health problems (PCOS) due to a change in the hormone secretion⁵. Many consumer products contain high level of BPA which are dangerous for human health such as- the thermal paper used for cash register and other receipts is another common source of BPA. Handling the paper leads to increased levels of the chemical in our bodies because it rubs off easily. Therefore, this study aims to analysis the harmful impact of BPA through thermal paper on human and regulation to ban the use of thermal coating on receipts and other paper which are used in daily life.

¹https://www.researchgate.net/publication/266397308_Biodegradation_of_bisphenol_A_by_the_freshwater_microalgae_Chlamydomonas_mexicana_and_Chlorella_vulgaris

²<https://www.sciencedirect.com/science/article/abs/pii/S0166445X11001251>

³<https://pubmed.ncbi.nlm.nih.gov/21605673/>

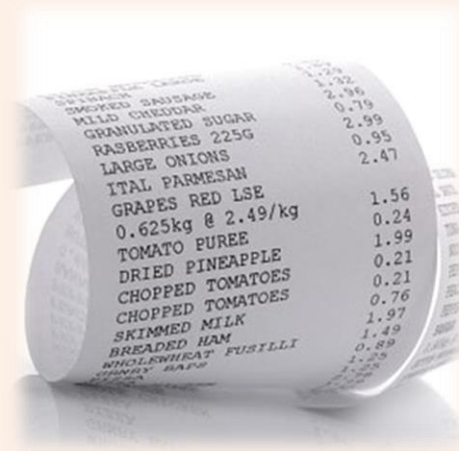
⁴<https://www.sciencedaily.com/releases/2016/04/160401111849.htm>

⁵[https://www.news-medical.net/health/Bisphenol-A-\(BPA\)-Health-Effects.aspx](https://www.news-medical.net/health/Bisphenol-A-(BPA)-Health-Effects.aspx)



Objectives

- To give an overall idea about the health effects of BPA and scenario of BPA containing products, specifically thermal papers available in the market.
- To detect the presence of Bisphenol-A (BPA) in thermal papers used in popular outlets in Bangladesh.
- To assess the country situation, uses, awareness, and understanding.
- To highlight the need of BPA regulation for thermal papers in Bangladesh.
- To inform the public and policy makers about hazardous impact of BPA on thermal paper on Environmental Health.
- To create scope for more academic research to assess the situation and possible solution.



Background

Bisphenol A is a synthetic organic compound that has the chemical formula $(\text{CH}_3)_2\text{C}(\text{C}_6\text{H}_4\text{OH})_2$ in the “diphenylmethane” derivatives of methane and bisphenols group, with two hydroxyphenyl groups. Commonly known as Bisphenol A (BPA) (Figure 1)⁶, a pernicious chemical compound. BPA can be derived from styrene, acrylonitrile, and butadiene and is a colorless and odorless crystalline solid which is poorly soluble in water. BPA is known as EDC as it mimics estrogen hormone properties⁷. According to BPA definition by European Union, it has also known as reprotoxic due to its adverse effect on sexual function and fertility in adult males and females⁸.

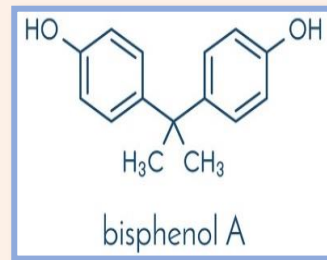


Figure 1: Chemical composition of

BPA exposure have linked to an increased risk for premature death. People with the highest levels of BPA in their urine had a 51% higher risk of dying during that period, primarily from heart disease, compared with people who had the lowest levels of BPA⁹. Moreover, BPA has association with a lot of health risk such as diabetes, obesity, high blood pressure, and heart diseases in humans. Pregnant women, infants and young children are at the greatest risk in various ways. Studies have shown that infants born to mothers exposed to BPA weigh up to half a pound less, on average, than infants born to unexposed mothers¹⁰.

⁶ [https://www.news-medical.net/health/Bisphenol-A-\(BPA\)-Health-Effects.aspx](https://www.news-medical.net/health/Bisphenol-A-(BPA)-Health-Effects.aspx)

⁷ https://en.wikipedia.org/wiki/Bisphenol_A

⁸ <https://www.sgs.com/en/news/2018/10/bpa-bans-and-restrictions-in-food-contact-materials>

⁹ <https://www.health.harvard.edu/staying-healthy/bpa-now-linked-to-premature-death>

¹⁰ <https://www.ehn.org/bpa-pollution-2645493129/what-is-bisphenol-a-where-is-it-found>

The study revealed that BPA from recipes seeps into the skin, dramatically increasing the amount of BPA in the human body. And the hand disinfectant increased the absorption rate. Additionally, commonly used skin care products also appear to increase the rate of absorption of BPA.

BPA was first prepared by Russian chemist Aleksandr Dianin in 1891 and synthesized in 1905 by Theodor Zincke from Marburg University, Germany¹¹. In early 1930s, British Biochemist Edward Charles Dodds found the estrogen mimicking comporment of BPA¹². He eventually developed a structurally similar compound, diethylstilbestrol (DES), which was used as a synthetic estrogen drug in women and animals until it was banned due to its risk of causing cancer in 1971. But the usefulness of BPA became evident by the middle of the 20th century and been used in mass production of many plastics related items since then.

Bisphenol A (BPA) is one of the highest volume chemicals produced worldwide and the global BPA market is projected to reach approximately 7.4 million tons by the end of 2023, increasing at a CAGR of around 3% per year in the period 2017-2023¹³. The thermal paper used for cash register, point-of-sale receipts, prescription labels, airline tickets and lottery tickets are a major source of BPA along with plastic toys, food



Figure 2: Cash receipts in thermal paper

¹¹ <https://www.packagingdigest.com/food-safety/history-bpa>

¹² https://en.wikipedia.org/wiki/Bisphenol_A

¹³ <https://www.prnewswire.com/news-releases/global-bisphenol-a-market-report-2018-analysis-2013-2017--forecasts-2018-2023-300757673.html>

storage containers, sports equipment, plastic bottles including water bottles, electronic equipment, dental sealants, CDs and DVDs.

Moreover, epoxy resins derived from BPA are used to line water pipes, as well as coatings on the inside of many food and beverage cans and in making thermal papers. About 60% of the global BPA produced is utilized for the production of polycarbonate resins while epoxy resin is the second largest BPA consumer, as of 2019¹⁴.

Exposure to BPA

The primary source of exposure to BPA for most people is through food or drink but there is thermal exposure as well. BPA can leach into food from the internal epoxy resin coatings of canned foods and from consumer products alongside with touching the thermal papers receipts.

In 2020, analysis of receipts from 39 countries has shown that BPA is still the most common compound used around the world with 69% samples containing this color developer. Among other tested bisphenols, Bisphenol S (BPS) was used as a color developer in 20% samples¹⁵.

Studies have found that receipts may play a much larger role in contributing to BPA exposures, particularly for individuals who regularly handle receipts as part of their occupation. Recent studies have found that individual thermal receipts from retailers and restaurants can contain a mass of BPA that is 250 to 1,000 times greater than the amount in a can of food¹⁶.

A significant increase in urinary total BPA concentration was observed for cashiers handling daily thermal paper receipts than individuals who did not handle BPA-containing paper¹⁷.

¹⁴ <https://www.chemanalyst.com/Pricing-data/bisphenol-a-29>

¹⁵ <https://www.sciencedirect.com/science/article/pii/S0269749120320947?via%3Dihub>

¹⁶ <https://www.ewg.org/research/bpa-coats-cash-register-receipts>

¹⁷ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4927604/>

BPA is absorbed readily when ingested, but the liver quickly metabolizes the chemical. It is excreted in the urine within 24 hours and does not accumulate in the body. In other words, if someone had a single exposure, it would be entirely gone from the body after a day. But repeated exposures as like in employees are necessary to have measurable levels on a regular basis¹⁸.

Scientists have determined two ways of how BPA coating can transfer to the skin and from there into the body. Possibilities being explored include oral exposure -- BPA moves from receipts onto fingers and then onto food and into the mouth and dermal exposure -- BPA from receipts is directly absorbed through the skin into the body¹⁹. A study published by Swiss scientists found that BPA transfers readily from receipts to skin and can penetrate the skin to such a depth that it cannot be washed off²⁰. This raises the possibility that the chemical infiltrates the skin's lower layers to enter the bloodstream directly. BPA has also been shown to penetrate skin in laboratory studies²¹. The European Food Safety Authority (EFSA) in 2015, set an exposure level of BPA from dietary intake, for infant which is 0.857 µg/kg (Body weight)/day and from non-dietary intake 0.015 µg/kg (Body weight-bw)/day.

US Food and Drug Administration (FDA) estimates that BPA exposure from use in food contact materials in infants and adults is 2.42 µg/kg bw/day and 0.185 µg/kg bw/day, respectively. In 2017, European Union set a temporary tolerable daily intake (TDI) equal to 4 µg/kg (bw)/day of which 10% allocates to exposure to BPA from toys²². In 2017, Commission Directive of EU set the migration limit of 0.1 mg/l was decreased to 0.04 mg/l in toys²³.

¹⁸ <https://www.poison.org/articles/plastic-containers-are-they-harmful>

¹⁹ <https://www.ewg.org/research/bpa-coats-cash-register-receipts>

²⁰ <https://pubmed.ncbi.nlm.nih.gov/20623271/>

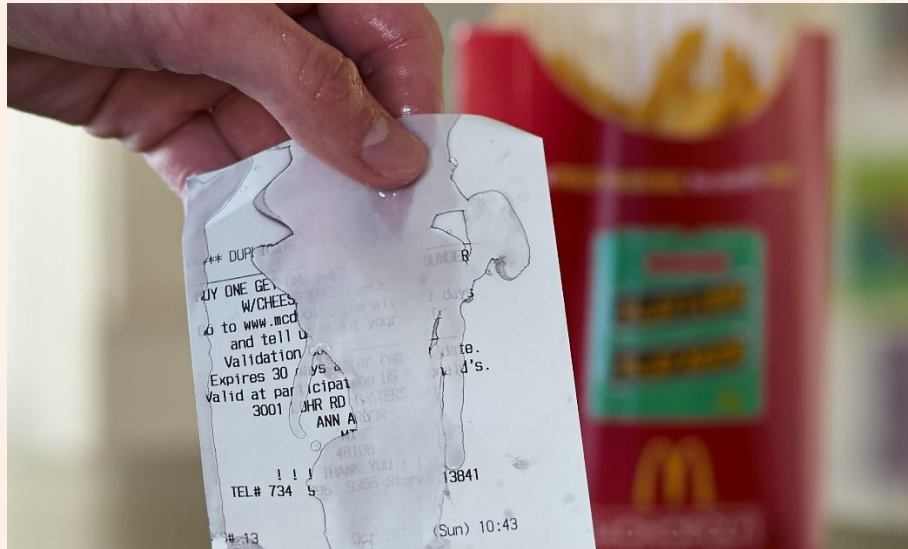
²¹ <https://www.tandfonline.com/doi/abs/10.1080/15287390801906824>

²² <https://bisphenol-a-europe.org/socio-economic-contribution/>

²³ <https://www.obelis.net/blog/new-limits-for-bpa-in-toys/>



However, recent studies have showed that, BPA intake from toys can reach up to 246 ng/kg (bw)/day which is very high risk as it has been reported that levels lower to 0.025 – 0.2 µg/kg (bw)/day can lead to severe health problems. European Union has published in BPA concentration in thermal paper to be reduced to less than or equal to 0.02% weight (200 ppm) before 2 January 2020²⁴.



“I’m a bit of a cash register receipt junkie. I obsessively stuff my wallet with those little slips of thermal paper telling me how much I spent, and it has to be paper—none of this e-receipt nonsense. But an article published in a journal give me some pause to rethink this habit”²⁵.

²⁴ <https://echa.europa.eu/documents/10162/370b5de7-9507-f1b4-edc6-80ef2e5cd781>

²⁵ <https://2020science.org/2014/10/26/bpa-cash-register-receipts-worried/>

Thermal paper properties

Printing mechanism

In today's life we cannot go without touching the thermal papers as it is found everywhere from local stationery shops to international band shops as a form of cash receipts. It is impossible to find anyone who has not gone to the ATM booth in a day. Even the shipping boxes, concert tickets are labeled with thermal papers

In 1960, thermal printing was discovered and went viral with the invention of fax machine²⁶. Nowadays, every office, shops or restaurants requires thermal printing as it is comparatively inexpensive. It does not require pricy ink or toner.

The process of thermal printing necessitates thermal printers with a heat-activated ink ribbon. While printing, this ribbon creates the images on thermal paper. These thermal papers are coated with a fluoran leuco dye which is a heat activated dye and BPA or alternative chemical such as BPA, BPE as a developer chemical. At the time of printing the thermal print head radiates heat by which microcapsule of the paper coating explodes and activates a reaction between dye and developer.

This in turn illustrates the image or text on the thermal paper²⁷. The detailed mechanism of the composition of thermal paper and color development after thermal reaction is presented in figure 12.

²⁶ <https://en.wikipedia.org/wiki/Fax>

²⁷ <https://www.ewg.org/research/bpa-coats-cash-register-receipts>

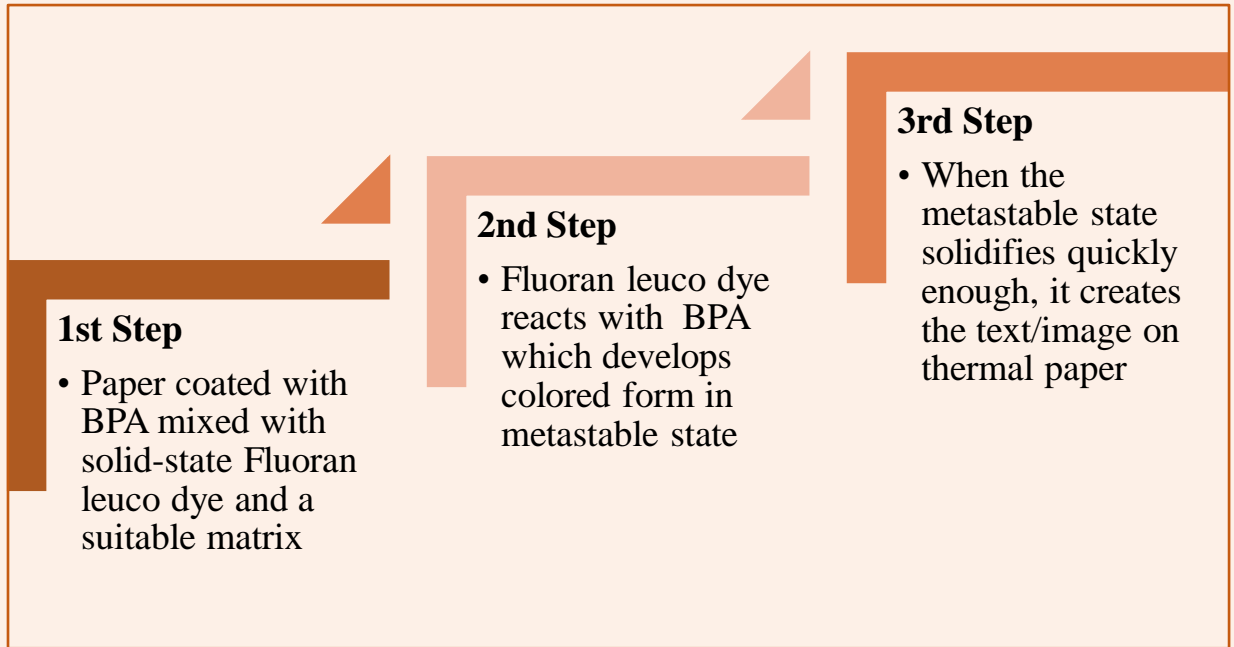


Figure 3:Printing mechanism on thermal paper

Dermal exposure of BPA through thermal paper

Biedermann and his group suggested that, surface area interaction of hand with thermal paper is more important factor rather than handling time of thermal papers for transferring BPA through skin to body²⁸. It is one of the main factors to BPA health exposures.

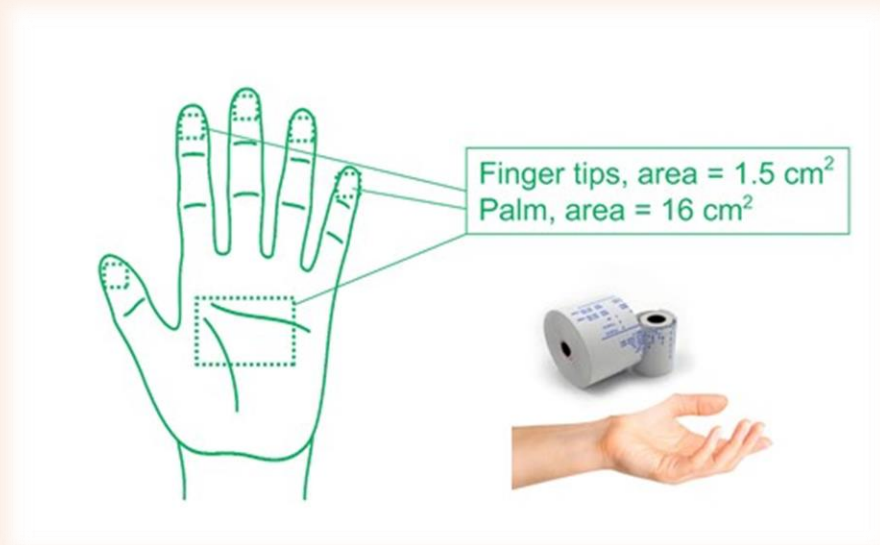


Figure 4: Dermal exposure of BPA

²⁸ <https://pubmed.ncbi.nlm.nih.gov/20623271/>

Impacts of BPA

Environmental Impacts

From the industrial plastics BPA runs off into the water system, from where it goes into the human body via the animals, we intake shown in the figure 5A²⁹. Likewise, when we throw away the thermal papers into waste bins, it directly goes into the landfills. When the rain comes, they leach to the surface water and thus hampering the ecosystem along with the food chain figure 5B.

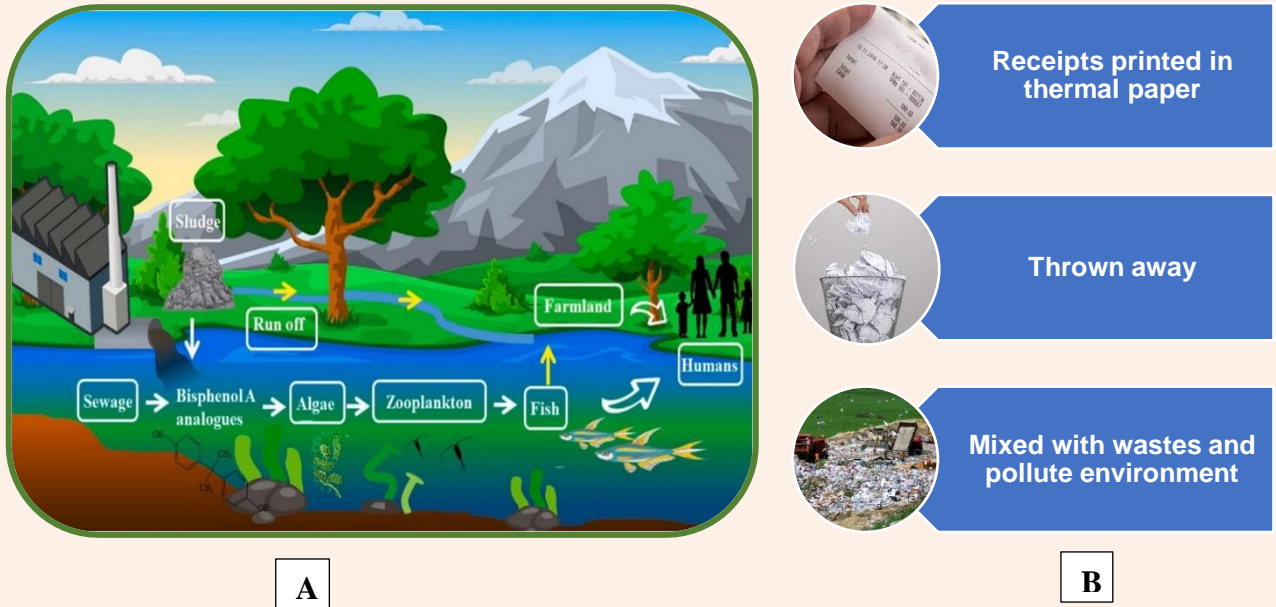


Figure 5: Environmental pollution by BPA
(A) By industrial waste (B) By cash receipts printed in thermal papers

²⁹ <https://www.sciencedirect.com/science/article/pii/S014765132031318X>

Human Health Impacts

The chemical BPA has been linked to numerous problems, including obesity, hormonal dysfunction, cancer, asthma, and reproductive disorders (Figure 6). BPA has related to hampering fetuses and children's prostate, behaviour and brain development, Thermal paper receipts contain BPA that indisputable, which is an endocrine disruptor. This chemical is toxic and can seep out of products and into human bodies through skin contact. BPA resembles the hormones of human bodies produce, that can results in developmental, reproductive and neurological disorders, according to The New York Times report, BPA has leaching properties, from food containers to diet or cash receipts to bloodstream through skin.

Altering Reproductive system

The effects of BPA on reproduction are multiple and involve alterations of both male and female function. It can affect the oestrous cyclicity of the female reproductive system. Decreased fertility may also occur because of BPA exposure³⁰.

Disrupting Endocrine System

Experts believe that BPA is an endocrine disruptive chemical (EDC) as the acts like a hormone in the body, disrupting normal hormone levels and development in fetuses, babies, and children. BPA also disturbs the development and function of the mammary glands³¹.

BPA exposure can cause one of the most common health problems in women (polycystic ovary syndrome), due to a change in hormone secretion³².

³⁰<https://www.hindawi.com/journals/ije/2019/4068717/>

³¹<https://www.sciencedaily.com/releases/2016/04/160401111849.htm>

³²[https://www.news-medical.net/health/Bisphenol-A-\(BPA\)-Health-Effects.aspx](https://www.news-medical.net/health/Bisphenol-A-(BPA)-Health-Effects.aspx)



Risk of High Blood pressure

It was found that there is about 27–135% greater risk of high blood pressure in people with high exposure to BPA levels³³.

Likelihood of Obesity

BPA is associated with a higher likelihood of obesity and abnormal waist circumference-to-height ratio. Obese women may have BPA levels 47% higher than those of their normal-weight counterparts³⁴. More and more studies found that 50-85% people and 59% people who have higher BPA exposure respectively are more prone to

obesity and large waist circumferences who have highest BPA. It is also a matter of surprise that this type of disease situation are also similar in children and adolescents^{21,35}.

Risk of Diabetes

Studies showed that higher BPA levels were linked to a 68–130% higher risk of type 2 diabetes³⁶. Moreover, people with the highest BPA levels were 37% more likely to have insulin resistance, a key driver of metabolic syndrome and type 2 diabetes³⁷.

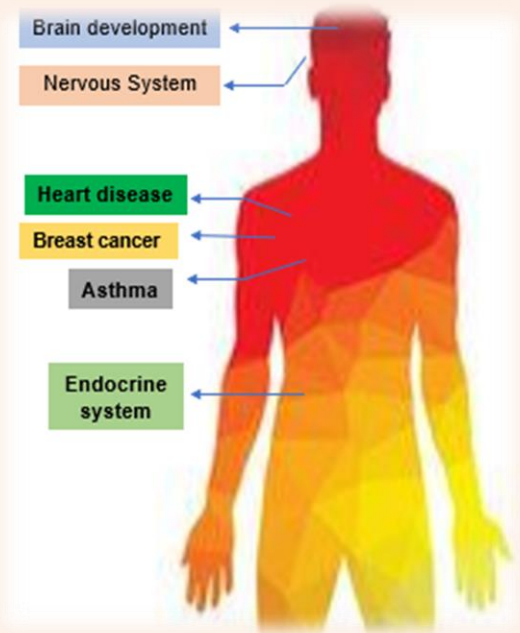


Figure 6: Health impacts of

³³ <https://www.healthline.com/nutrition/what-is-bpa#obesity>

³⁴ <https://pubmed.ncbi.nlm.nih.gov/15118266/>

³⁵ <https://pubmed.ncbi.nlm.nih.gov/22990270/>

³⁶ <https://pubmed.ncbi.nlm.nih.gov/21956417/>

³⁷ <https://pubmed.ncbi.nlm.nih.gov/22090277/>

Cancer

Exposure to BPA appears also to be linked to the higher incidence of uterus, ovarian, prostate and testicular cancers³⁸.

Asthma

A study by Columbia University investigated 568 women who were part of a study on mothers, newborns and environmental exposures from BPA. BPA levels in urine were measured during the third trimester of pregnancy and again when the children were 3, 5 and 7 years of age, finding at each measurement that 90 percent of the children had BPA exposure and that these children had an increased risk of wheezing and asthma³⁹.

Nervous system

Duke University researchers published a study in the Proceedings of the National Academy of Sciences that found that BPA may impair the development of the central nervous system by suppressing a gene that is vital to nerve cell function.

Environmental Research from the University of California – Berkeley showed that boys who were exposed to higher BPA levels as a fetus or during their early childhood were more likely to be suffering from anxiety, aggression, depression and hyperactivity by age of 7, though this association was not present with girls. It has also been found that childhood urinary BPA concentrations were associated with increased externalizing behaviors, including behaviors problems, in girls at age of 7 and increased internalizing behaviors and inattention and hyperactivity behaviors in boys at age of 7⁴⁰.

³⁸ <https://onlinelibrary.wiley.com/doi/full/10.1111/1541-4337.12388>

³⁹ <https://cnprc.ucdavis.edu/bpa-and-female-development/>

⁴⁰ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3805756/>



Cardiovascular diseases

A higher concentration of BPA in urine is related to certain cardiovascular conditions such as heart attack, angina, and heart problems. Some reports have shown that acute BPA exposure causes the development of an irregular heart rhythm, and constant exposure to BPA resulted in atherosclerosis and changes in blood pressure. Therefore, BPA exposure is considered to be a risk factor for heart-related disorders²⁰. Moreover, a survey in 1,455 Americans linked higher BPA levels to an 18–63% greater risk of heart disease⁴¹.

Impacts on Animals

BPA research has also been done on animals. Tufts University, USA found in rat study that if the rat is exposed to BPA with a similar level to human during rat's lactation period, it increases the chances of developing breast cancer. Furthermore, BPA can be linked to mammary gland carcinogen⁴². A study published by the University of California found that after the fetuses of pregnant rhesus macaque monkeys were exposed to levels of BPA designed to replicate human exposure, there were changes observed in the lungs that increased the potential for the development of asthma⁴³.

⁴¹ <https://pubmed.ncbi.nlm.nih.gov/18799442/>

⁴² <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3764086/>

⁴³ <https://cnprc.ucdavis.edu/bpa-and-female-development/>



Global Regulations on BPA

Worldwide many countries had already banned the use of BPA in baby bottles and in food packaging. Countries mentioning Canada, USA, Australia, European Union, France, Denmark, Germany, Belgium, South Africa banned BPA from baby bottle and among the Asian countries Japan, China, Malaysia had banned BPA from Food packaging and baby sippy cups, bottles. In India Bureau of Indian Standards (BIS) banned BPA use in feeding bottles of babies in 2015 but till now there is no regulations over thermal papers BPA contents.

Table 1: Global regulations on BPA in thermal papers

Country	Regulation & year
European Union	BPA concentration in thermal paper to be reduced to less than or equal to 0.02% weight (200 ppm) before 2 January 2020 ⁴⁴
Japan	Banned BPA since 2001 ⁴⁵
Belgium	Banned BPA in thermal papers in 2011 ⁴⁶
South Korea	Proposed to restrict BPA in the thermal paper by May 2022 or later. ⁴⁷
Switzerland	Banned both bisphenol A (BPA) and bisphenol S (BPS) in the thermal paper – in a concentration of 0.02% or higher by weight – implemented in January 2020 ⁴⁸
Connecticut State, USA	The act prohibits the manufacture, sale, or distribution of thermal receipt or cash register receipt paper containing BPA in Connecticut effective on 1 October 2013 ⁴⁹
Illinois State, USA	Illinois becomes the latest state in the US to ban BPA in thermal paper effective on January 1, 2020 ⁵⁰ .

⁴⁴ <https://echa.europa.eu/documents/10162/370b5de7-9507-f1b4-edc6-80ef2e5cd781>

⁴⁵ https://www.epa.gov/sites/production/files/2015-09/documents/bpa_ch2.pdf

⁴⁶ https://en.wikipedia.org/wiki/Bisphenol_A#Regulation

⁴⁷ <https://www.sgs.com/en/news/2021/03/safeguards-03121-south-korea-proposes-to-restrict-bpa-in-thermal-paper>

⁴⁸ https://www.plasteurope.com/news/PLASTICS_AND_HEALTH_t242747/

⁴⁹ <https://chemicalwatch.com/8123/connecticut-becomes-first-us-state-to-ban-bpa-thermal-paper-receipts>

⁵⁰ <https://www.sgs.com/en/news/2019/09/safeguards-12519-us-state-of-illinois-bans-bpa-in-thermal-paper>

In the table 1 , the countries and regulations of BPA on thermal papers have been mention. But Bangladesh has no limit or standard regulations over the use of BPA in thermal papers / food packaging / baby products.

Methodology

In preparing this comprehensive report, the appropriate study of the data was collected from primary and secondary sources. For primary source, extensive survey and lab test were done and for literature review, data from reliable online research paper, journals, news articles etc. was collected on BPA properties, thermal paper mechanism add adverse impacts were collected from online by researching several scientific journal articles, reports and grey literatures. The primary data collection methodology has divided into two parts – Survey and Laboratory works which have elaborated below-

Baseline Survey

The baseline survey had been conducted through questionnaires and carried out from February 2019 to January 2020 on total 1350 people (Consumer and retailers). Set of structured questionnaires were designed to ensure getting all relevant data from targeted segment. Surveyed 1350 population included 1310 consumers and 40 retailers (food shops, restaurants, chain shops, etc.).

Data & sample collection

The ESDO research team had made physical visits to various locations in Dhaka (New Market, Chawk Bazar, Mohammedpur Town Hall, Lalmatia, Gulisthan, Motijhile, Gulshan-1. & 2, Uttara, Mirpur (1,2 and 10) and conducted questionnaire survey amongst consumers and shop owners including their demographics and awareness level regarding BPA and

thermal papers. Cash receipts were collected from local shops (fast food, restaurants, chemists, ect.) and ATM in the study areas. Team collected 43 receipts after survey. Then 36 samples were sent to University of Minnesota Duluth, USA in zip locked bags through DHL.

Laboratory Tests

The laboratory tests had been accomplished at the analytical laboratory at the University of Minnesota Duluth, USA. The samples were weighed, measured and photographed. After that, the samples were analyzed for BPA using sensitive by using standard BPA test method (High-performance liquid chromatography-HPLC⁵¹ with CoulArray detection) (Figure 7). There are no quality assurance issues with the data and all quality control (QC) criteria were met.

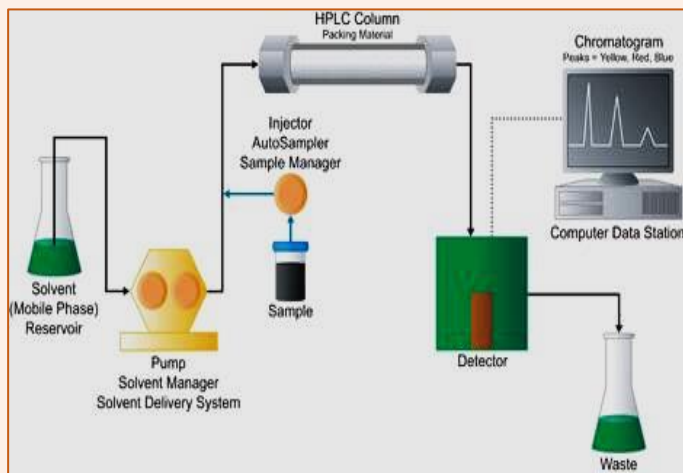


Figure 7: High Performance Liquid Chromatography (HPLC) system

⁵¹ https://www.waters.com/waters/en_US/How-Does-High-Performance-Liquid-Chromatography-Work%3F/nav.htm?cid=10049055&locale=en_US

Data Analysis

Demographic Data Analysis:

Age and gender of surveyed population

Among the 1310 surveyed consumers 728 were males (55.6%) and 581 (44.4%) were females (Figure 3). Most of consumers (77.3%) 1001 were within 30 to 50 years old.

Income level of targeted audience of Survey

The survey was conducted in different classes of people based on their income. Among 1350 consumers, 810 (60%) persons were middle income people, 472 (35%) persons were low income and the rest 68 (5%) people were high income people (Figure 9).

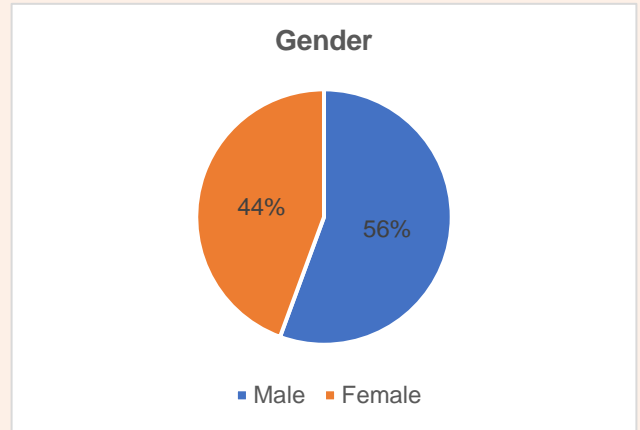


Figure 8: Gender of survey population

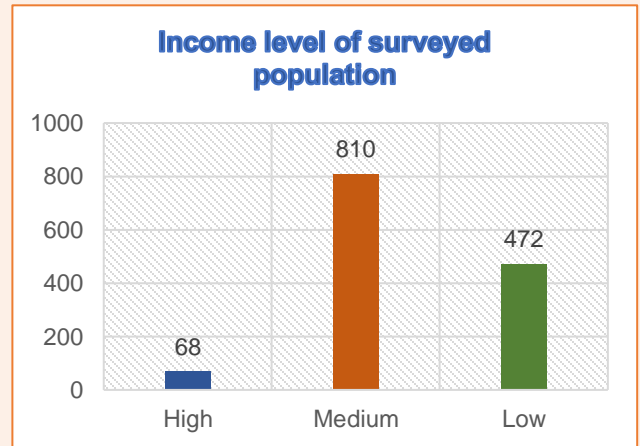


Figure 9: Income level of consumers

Education of surveyed population:

The survey was conducted in different classes of people. Survey questionnaires were also made based on educational background. 853 (63.2%) people had higher education and 405 (30%) people had high school education.

Description of Collected thermal papers

Among the 36 sample receipts, 5 receipts are from ATM booth, 6 from fast food shops, 2 from bakery and 3 each from restaurants, stationery, sweet, brand and pharmacy (Table 2). 3 receipts are collected from ATM machines, 2 from cash register machines and rest of the 8 receipts are from card machines (Table 3, Figuer 10). Figure 6 illustrates altogether the cash receipts shops and machines.

Shops	Number of receipts
Restaurant	3
Brand shop	3
Fast food shop	6
Super shop	4
Pharmacy	3
Food shop	4
ATM	5
Stationary shop	3
Sweet shop	3
Bakery	2
Total	36

Table 2:Types of shops and number of cash receipts

Machines	Number
ATM	5
Cash register	15
Card machine	16

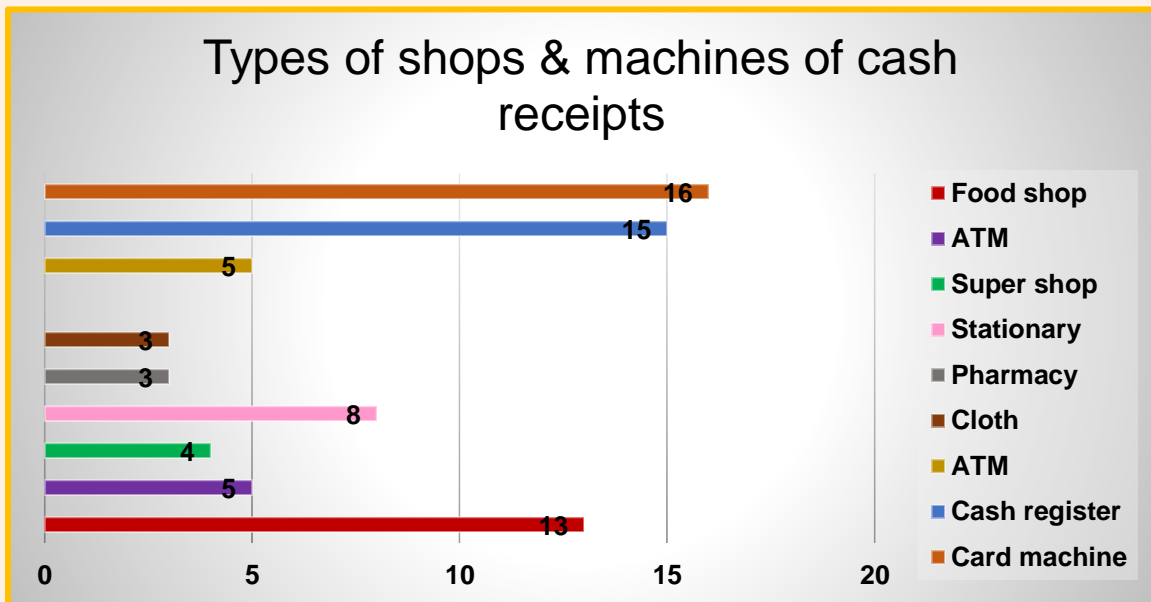


Figure 11: Types of shops & machines of cash

Knowledge and awareness level about thermal paper

Surveyed population recognized the thermal papers as slips but unfortunately, 0% of them have no knowledge on thermal coating on paper and its harmful effects by touching/rubbing the surface area of these kind of papers.

Awareness level regarding BPA

From the both consumer and retailer's questionnaire survey, it is evident that most of them are not aware about BPA in products. Only 67 persons out of 1350 (5%) have some idea about BPA in plastic and other products though they have very less knowledge about the harmful effects of BPA (Figure 12).

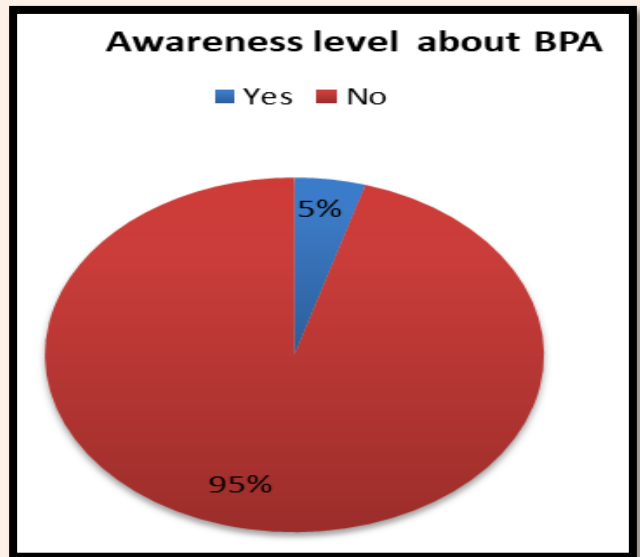


Figure 12: Awareness level of consumers and retailers about BPA

Public recommendations on BPA regulation

From the present study, 55% of the people said it is urgent to create awareness about the negative effects of BPA in products. 39% people said, government also should take initiatives and make regulations on BPA in products (Figure 13).

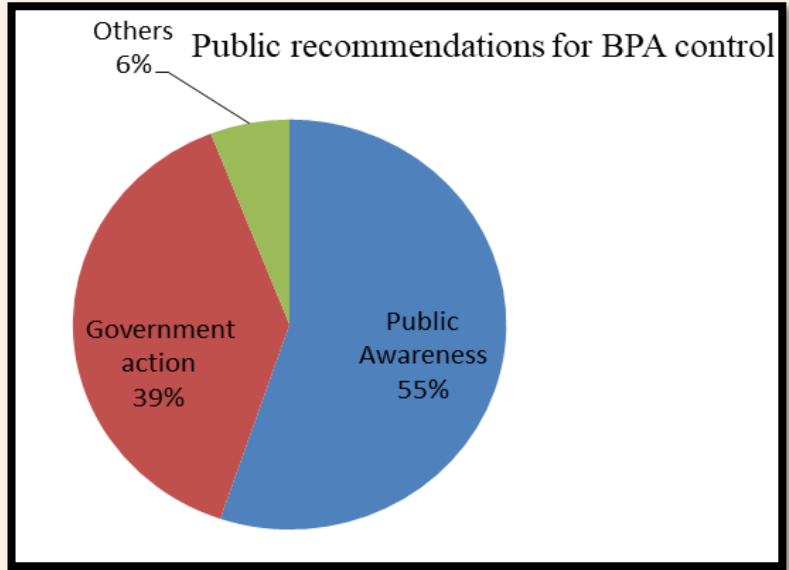


Figure 13:Public recommendations for BPA

Laboratory test results

Table 4 and figure 14 specifies that laboratory tests of thermal papers indicated the presence of BPA in quantities ranging from 10 – 53 $\mu\text{g}/\text{cm}^2$. All the samples have BPA which shows us the severity of the situation. Figure 15 illustrates percentage of BPA relative to mass of receipt weight separately.

Serial	Sample Type	Total mass of BPA on receipts (mg)	Size of the receipts (cm^2)	Mass of BPA relative to mass of receipt weight	Mass of BPA relative to surface area of receipt (μg of BPA/ cm^2)
1	Restaurant	16.2 - 20.7	1006	2.8%	35.9
2	Colth shop	24.8 - 27.2	1568	3.7%	38.4
3	Fast food shop	14.3 - 20.6	1575	1.8%	14.9
4	Super shop	28.2 - 31	2671	2.1%	10.1
5	Pharmacy	6.9 - 10.8	902	1.8%	25.7
6	Food shop	7.6 - 9.36	591	2.2%	48.6
8	ATM	14.1 - 28.8	1249	2.9%	19.1
11	Stationary shop	3.2 - 4.89	382	1.6%	52.9
12	Sweet shop	2.7 - 2.98	400	0.8%	27.3
13	Bakery	9.7 - 11.2	1023	2.2%	35.8

Table 4: Laboratorial results of thermal papers of different shops

Total mass of BPA relative to surface area of receipts ($\mu\text{g}/\text{cm}^2$)

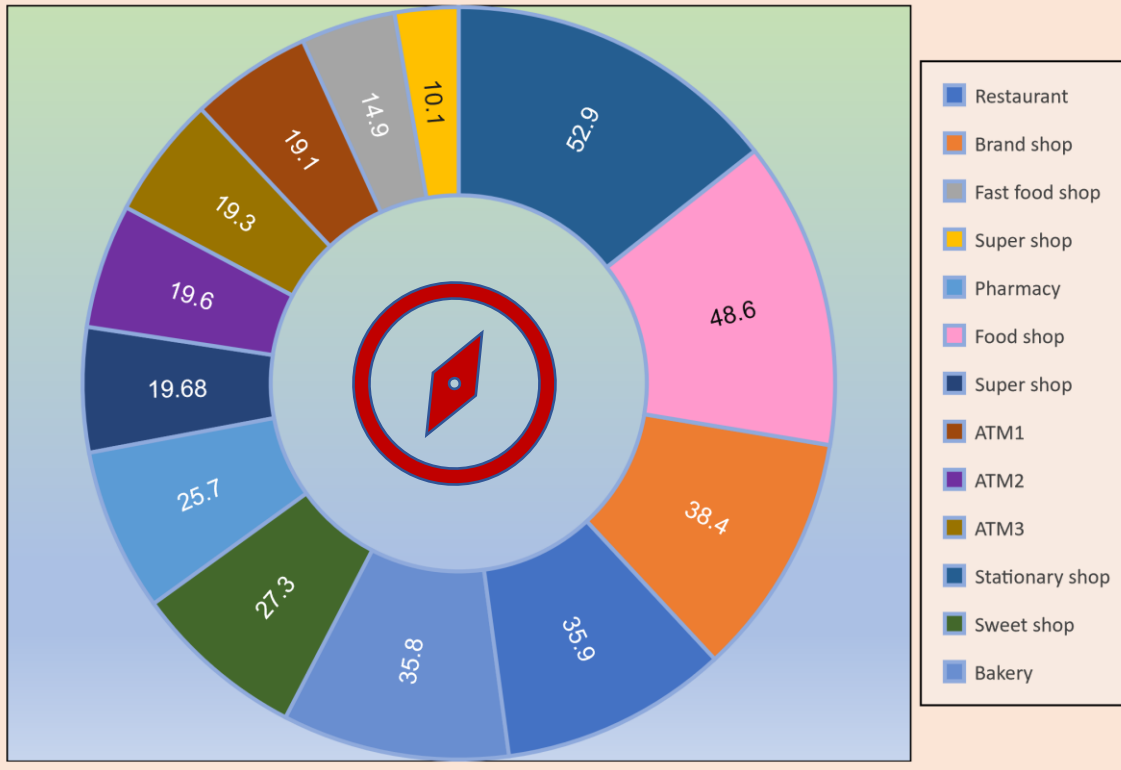


Figure 14: Total mass of BPA on receipts ($\mu\text{g}/\text{cm}^2$)

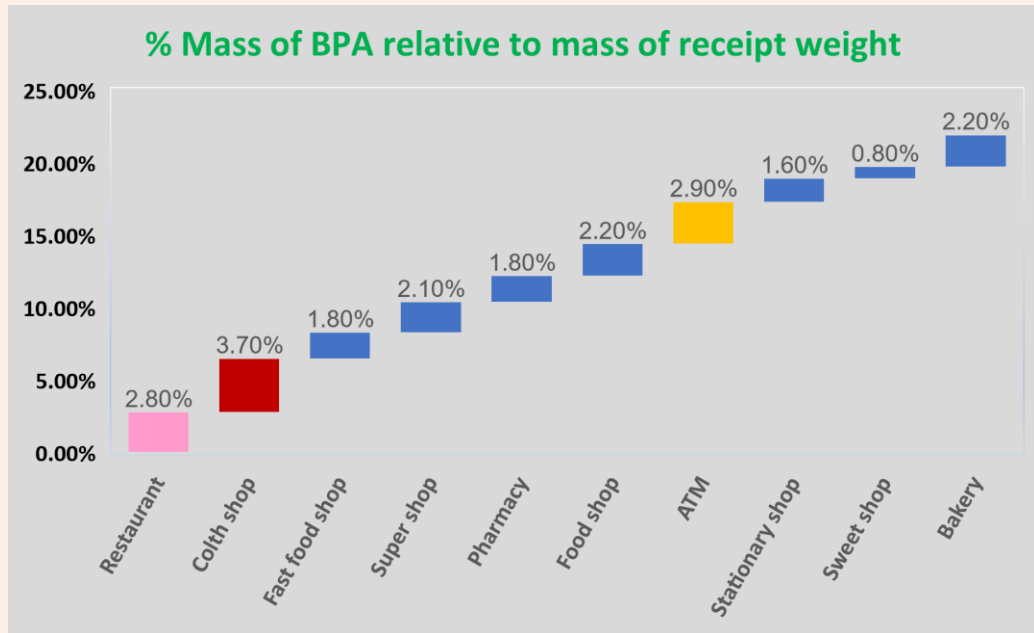
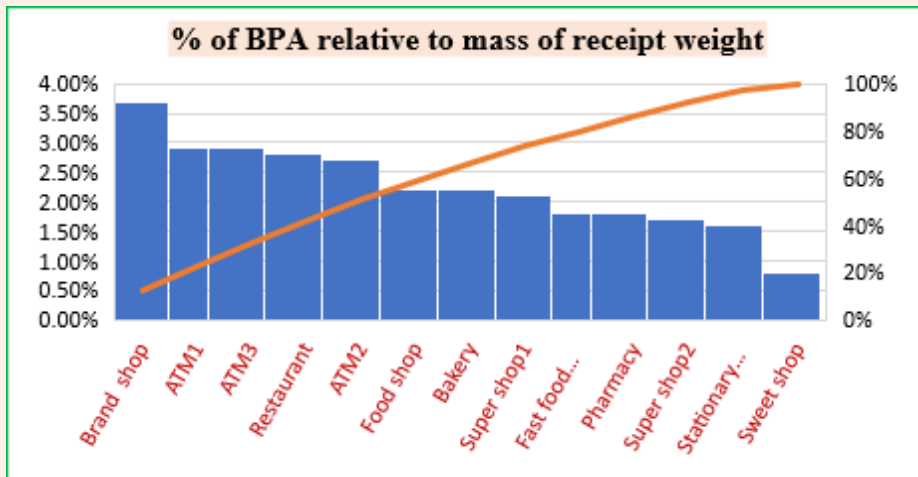


Figure 15: % of BPA relative to mass of receipt weight



Laboratory Data Analysis

According to European Union the percentage of BPA in thermal paper should not over **200 ppm/ 0.02%** by weight⁵² but the sample are showing **0.08% - 3.7%** by weight which is very alarming. It showed, this is high time, a proper and broad national assessment is needed to analysis actual presence rate of BPA in overall.



⁵² <https://echa.europa.eu/documents/10162/370b5de7-9507-f1b4-edc6-80ef2e5cd781>

Recommendations

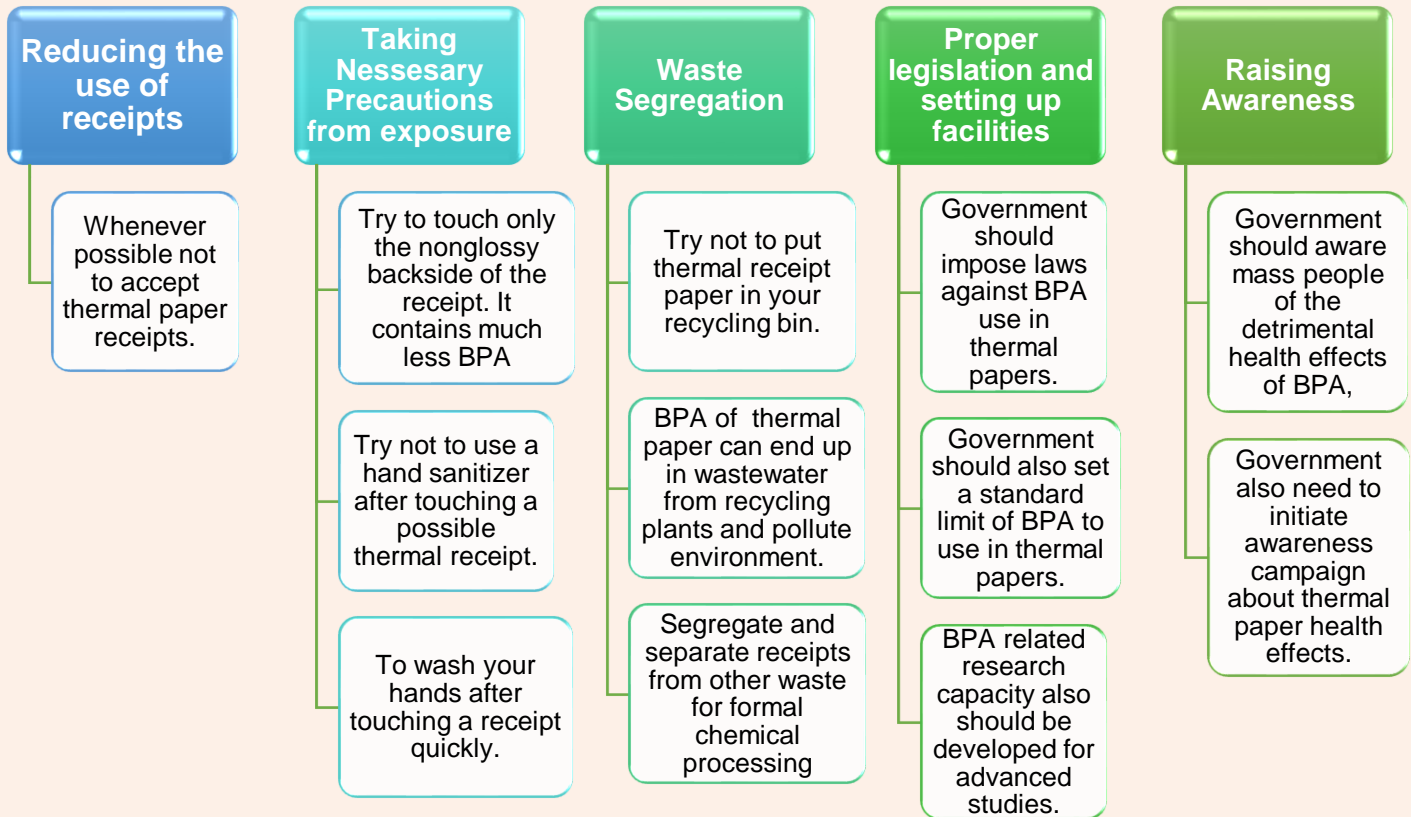


Figure 16: Recommendations

Conclusions

BPA is one of the major concerning chemicals nowadays. It affects infants to adults and can be found everywhere in the human lifestyle and the environment as well. Before the situation gets worse the government of Bangladesh needs to regulate BPA in thermal papers very strictly.

With all limitations, ESDO completed this important study as a startup. In this study, we found the presence of a high level of BPA in thermal paper. Although this few samples testing is not sufficient for drawing conclusions about the toxicity of thermal paper overall. However, this study finding is good enough to give maximum attention and emphasis to action immediately.

Moreover, a directive is requiring to reduce and phase out the use of thermal paper. The reduction and ultimate elimination of thermal paper will reduce human exposure to BPA and BPS as well as future recycling of chemicals by recycled paper manufacturing and environmental impact through its lifecycle.

References

A number of studies have shown that BPA can transfer from thermal paper (ie cash receipts) to the skin where it can then migrate into the bloodstream. Is this something to be worried about? <https://www.mcgill.ca/oss/article/health/turning-heat-thermal-paper-receipts>

More than 100 epidemiology studies suggest associations between BPA exposures and an increased risk of adverse Health outcomes including cardiovascular diseases, obesity, diabetes and others <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5453537/>

Recent studies have found that individual thermal receipts from retailers and restaurants can contain a mass of BPA that is 250 to 1000 times than the amount in a can of food. <https://www.pca.state.mn.us/green-chemistry/bpa-thermal-paper>

There is another way that BPA can potentially get into your body through, and that's through your skin. BPA is used as a developer for heat-sensitive ink in many cash register receipts that use thermal paper. It's applied as a surface coating, <https://2020science.org/2014/10/26/bpa-cash-register-receipts-worried/>

New report: 9 out of 10 receipts contain toxic BPA, a new report by HealthStuff.org exposes a danger at many checkouts counters-toxic receipts. They found toxic bisphenol A (BPA) or its chemical cousin bisphenol S (BPA) in 93% of the receipts tested. <https://saferchemicals.org/2018/01/17/new-report-9-out-of-10-receipts-contain-toxic-bpa-or-bps/>

Now high levels of BPA exposure have been linked to an increased risk for premature death from any cause, according to a study published online Aug. 17, 2020, by *JAMA Network*. [BPA now linked to premature death - Harvard Health](#)

BPA may cause adverse health effects because of its endocrine activity. General population exposure to this compound mainly through diet is well documented. Thermal paper was also identified as a source of BPA through dermal intake. [Occupational exposure of cashiers to Bisphenol A via thermal paper: urinary biomonitoring study \(nih.gov\)](#)

BPA can have an impact on wildlife, particularly on aquatic life in both freshwater and saltwater areas, which become reservoirs for contaminants. BPA has been known to mimic hormones and disrupt endocrine systems, including the kidney, liver, and gallbladder. <https://www.kangovou.com/bpa-effects-bento-lunch-boxes/>

More information



twitter.com/esdobd

facebook.com/esdobd

info@esdo.org

