A model of Bieber Fever: are our children safe?

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A novel infectious disease has recently arisen and has begun spreading through populations all over the world. Unlike other diseases, which affect mostly under-developed countries, this one has taken hold in the developed world, specifically in the United States and Canada. This disease is Bieber Fever.

Bieber Fever is defined as an individual's exorbitant obsession with Justin Bieber (1). It has similar properties to other infectious diseases, such as a rapid rate of transmission in large populations and it has debilitating symptoms associated with it. Symptoms of this disease include uncontrollable crying and/or screaming, excessive purchasing of memorabilia, making poor life choices because of Justin Bieber (for example getting a tattoo of Justin Bieber's name/face), and distraction from everyday life, among many others.

Similar strains of the disease have arisen in the past for boy bands such as New Kids on the Block and Backstreet Boys, in addition to other solo artists such as Justin Timberlake. However, none of those cases reached the same magnitude and affected, at such a young age, a large portion of the population as with Bieber Fever. To understand the spread and severity of this disease, first we need to understand its origin.

Justin Bieber was born on March 1st, 1994 in London Ontario, but was raised in Stratford Ontario. He seemed to have an affinity for music early on; he taught himself to play the drums, guitar, and knew how to play the trumpet and keyboard (2). He was signed to Def Jam Records in 2008 at the young age of 13, after being discovered because of videos he posted on the online media share website YouTube. Scooter Braun, a talent agent who has worked with the likes of Jermaine Dupri, saw Justin Bieber's videos and worked to get him meetings with Usher and Justin Timberlake (2) and eventually a record deal.

Following that, his career exploded. Through YouTube, he already had a large local fan base and it simply continued to expand with his increased exposure. Intense media exposure has been responsible for accelerating his career such that his music video for "Baby" is one of the top videos on YouTube (3), he has an album at the number five position on the Billboards Top 200 for 2010 (4) and is now one of the most searched names on the internet (5).

To help illustrate the extent of media buzz surrounding him, Figure 1 shows the

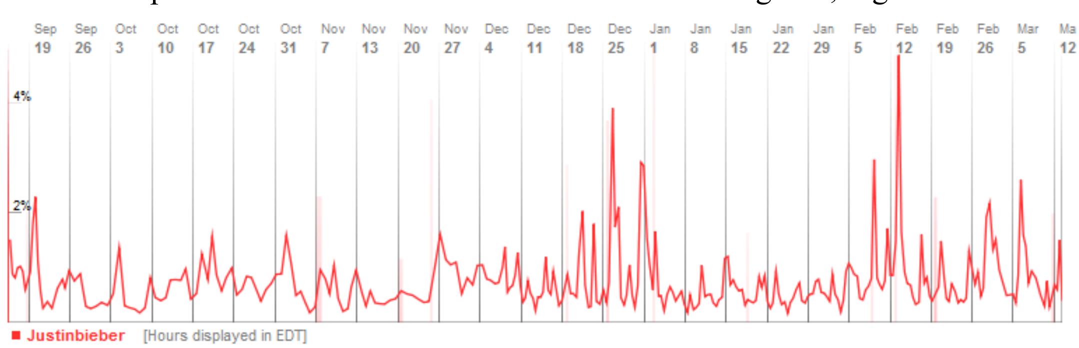


Figure 1. Percentage of Twitter tweets related to Justin Bieber over a period of 180 days (from September 2010 to March 2011). The figure was created using the Trendistic application.

percentage of tweets related to Justin Bieber on the popular media share website Twitter over a 180 day period (from approximately September 12, 2010 to March 12, 2011) (6). Consistently, 1% of tweets are related to him and on one occasion, the number of tweets increased to approximately 4%. These peaks are often related to major media events surrounding him. For example, the peak around the 11th of February 2011 where he reached 4% corresponds to the release of his movie *Justin Bieber: Never Say Never*.

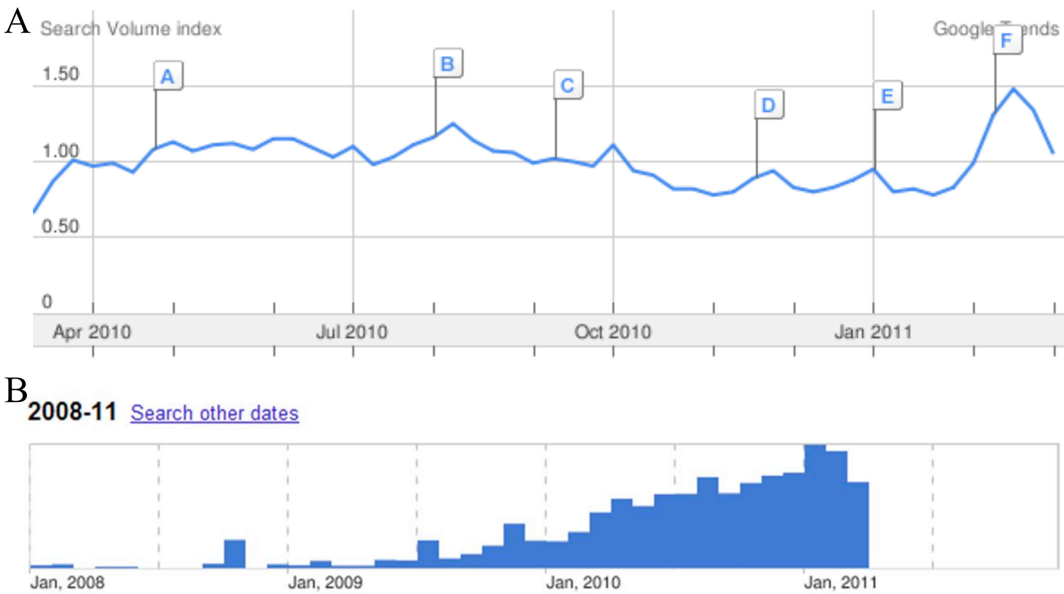


Figure 2. Google trends related to Justin Bieber. Panel A shows the average amount of daily search traffic related to Justin Bieber, standardized to 1 on the *y*-axis over the period from April 2010 to March 2011. This graph was created using the Google trends application. Panel B shows the number of search results related to Justin Bieber based on the date posted between January 2008 and March 2011. This bar graph was created using the timeline search option in Google.

Similarly, Figure 2A shows the trends of Google searches related to Justin Bieber over the past 12 months (April 2010 – March 2011). The *y*-axis shows the average amount of daily search traffic related to Justin Bieber, scaled to 1.0 (7). Therefore, any peaks above 1.0 represent an increase in Justin Bieber searches. The labels in the figure represent some of the major news events related to him. For example, F represents a story on Justin Bieber's lack of Grammy nominations (8) and the peak in February could be attributed to the release of *Never Say Never* as well. Panel B of Figure 2 illustrates the number of search results related to Justin Bieber over the past three years (8).

Moving away from media buzz, the sheer body of musical work Justin Bieber has created is also astounding. To start he has released a total of five albums, three of which contain original songs and two of which are remakes and remixes. A total of 20 singles from these CDs have been released, 10 of which have accompanying music videos. In 2010 alone, he was nominated for 28 music awards and he won 19 of them (9).

Outside of music, he released a concert movie called *Justin Bieber: Never Say Never* on February 11, 2011. In the United States and Canada on its opening weekend it made just under $30 million (11). Collectively, it has made approximately $91 million in theatres worldwide, with approximately $72 million of that being from domestic sales (12).

He has published two autobiographical books himself and another 13 were published about him by other authors. In addition, he has made innumerable television, magazine and radio appearances, which have ensured he stays in the public eye at all times. Through mere constant exposure, it created the perfect conditions for the diseases and young women soon becoming obsessed.

Since this strain of the disease is not well documented, because of its relative novelty in society, we will specify certain disease features that we will focus on in this study. First of all, we recognize Bieber Fever may infect a small proportion of the male population; however, we will only be addressing its spread in the female population since they represent the largest portion of his fan base. In addition, we will only consider individuals in the 5 – 17 year age range, since it encompasses the largest portion of his fan base.

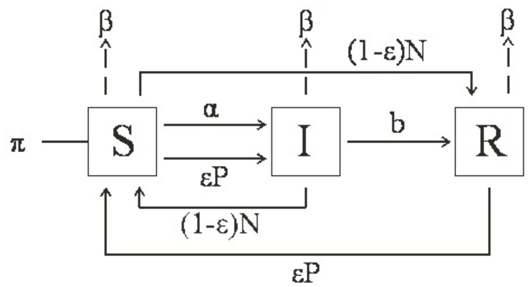


Figure 3. The basic Bieber Fever model.

Model

We will model the disease's spread using an SIR model with a couple variations. The compartments represent the susceptible (*S*), infected (*I*) and removed (*R*) populations. In this model, the removed category represents individuals who are "immune" to infection, i.e. those who have lost interest in Justin Bieber; however, this compartment is not an end stage as "immunity" can be lost. In addition, beyond the typical SIR model, we have also incorporated the effect of the media on transmission.

We assume there is a total amount of media events (*M*) and a certain proportion (ε) is positive (*P*) and the rest is negative (*N*). This is illustrated in equation 1. Media events would include the release of any new albums, singles, movies, dolls, or interviews with media companies on either radio, television or in magazines/newspapers. The proportion simply represents how often positive media events versus negative media events are broadcast to the public.

$$M = \varepsilon P + (1 - \varepsilon)N \tag{1}$$

The flow of individuals through the disease is as shown in Figure 3. Individuals enter the susceptible population by a given birth rate (π). They then become infected through one of two routes. They can either become infected by coming in contact with individuals infected with Bieber Fever (transmission rate, α). Alternatively, individuals can become infected through excessive positive media exposure (εP).

Infected individuals can then recover by losing interest in Justin Bieber (rate of recovery, b). Individuals can also be removed at any point by maturing beyond the age of 17 years (maturation rate, β).

Beyond the simply flow from susceptible to infected to recovered, media can also affect the flow of individuals between compartments. Positive media can also remove the immunity of an individual in recovered, making them susceptible again by restoring their interest in Justin Bieber. Conversely, negative media can decrease excitement about Justin Bieber in the infected individuals thus returning them to the susceptible population. Lastly, negative media can also push a susceptible individual into the recovered population by completely removing interest in him.

The ordinary differential equations (ODEs) for this model are outline below:

$$\frac{dS}{dt} = \pi - \alpha SI - \varepsilon PS + (1-\varepsilon)NI - \beta S + \varepsilon PR - (1-\varepsilon)NS \tag{2}$$

$$\frac{dI}{dt} = \alpha SI + \varepsilon PS - (1-\varepsilon)NI - bI - \beta I \tag{3}$$

$$\frac{dR}{dt} = bI + (1-\varepsilon)NS - \varepsilon PR - \beta R \tag{4}$$

An interesting property of our model is that at equilibrium, the number of infected individuals will constantly increase so long as the media term (εPS) is positive. In other words, so long as there is positive media about Justin Bieber, the disease can breakout without anyone initially having it. Therefore, our disease free equilibrium is not a stable equilibrium.

Beyond the disease specifics mentioned above about age and sex, we made other assumptions about the disease. These are that the disease can only be transmitted through contact with infected individuals or through media exposure and that these interaction can be described by mass action modeling. Similarly, we assumed that each individual experiences frequent and constant media exposure. We believe this is a valid assumption, since with the internet, television, radio, magazines/newspapers and society's dependence on portable media devices these days, individuals can constantly be exposed to media. Lastly, we assumed the proportion of media exposure and the number of media events remains constant over time.

The values we assigned to each parameter are listed in Table 1. We modeled the spread of Bieber Fever in an initial population of 1000 individuals. The lifespan in the model is 12 years ($1/\beta$) since we are looking at an age range of 5-17 years. We also assumed it takes approximately two years to get bored of listening to his music and playing with his dolls. To estimate the remaining model parameters, we looked at information available online.

We used a birth rate of 10 people per month initially, to give us an idea of how the model would run. However, we recognize this value is high and we will alter this value to see the effects on the model. We assumed a greater proportion of media exposure would be positive since his record label would be more interested in keeping his image positive rather than negative, which is why we assigned ε to be 0.75. Even though more media exposure would be positive, that might not correspond to a greater amount of positive media events occurring. It simply means positive stories are being broadcast to the public more often than negative stories.

Considering the number of albums, singles, movies and books released in 2010 alone, we assumed positive media events were occurring fairly often and assigned *P* a value of twice a month. However, gossip magazines thrive on slandering celebrity images so we also assigned a relatively high value to *N*, at once a month.

Table 1. Parameter values for the Bieber Fever Model.

Variable/Parameter	Symbol	Value	Units
Susceptible	S	1000	people
Infected	I	0	people
Recovered	R	0	people
Birth rate	π	10	people/month
Transmission rate	α	8.3e-4	$people^{-1}$ $month^{-1}$
Maturation rate	β	1/144	$month^{-1}$
Rate of recovery	b	1/24	$month^{-1}$
Media proportion	ε	0.75	$month^{-1}$
Positive media exposure rate	P	2	$month^{-1}$
Negative media exposure rate	N	1	$month^{-1}$

Results

As already mentioned, because of the positive media term in the infected ODE, Bieber Fever can arise in a population without anyone being initially infected. Therefore, for all the simulations, unless otherwise indicated, the entire population will begin susceptible.

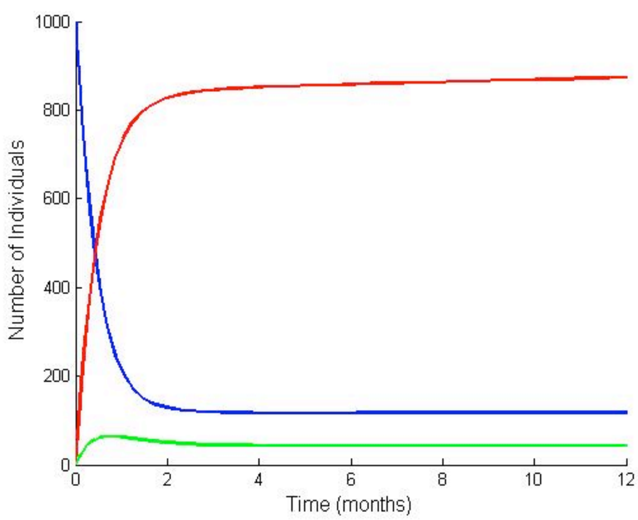


Figure 4. Bieber Fever model results for the parameters assigned in Table 1. The lines represent the susceptible (blue), infected (red) and recovered (green) populations.

Figure 4 shows the resulting populations when we run the model for a year. The line in red represents the number of individuals in the infected population, blue the susceptible population and in green the recovered population.

To ensure there was no significant effect of increasing the initial value of the infected population. The results of the model are shown in Figure 5. We ran the model with initial infected population of 0 (red), 50 (purple), 100 (green) and 200 (blue) individuals.

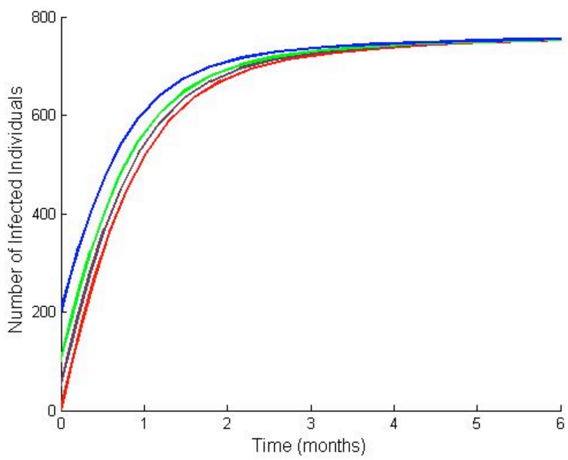


Figure 5. Bieber Fever model results for the infected population when the initial infected population size is 0 (red), 50 (purple), 100 (green) and 200 (blue).

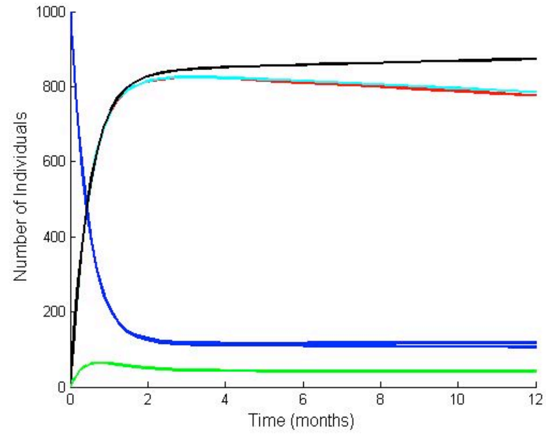


Figure 6. Bieber Fever model results for all populations with altered birth rates (π). The blue lines represent the susceptible population and the green the recovered. The lines representing infected population vary in color depending on the value assigned to π (black=10, blue=1 and red=0.1)

We recognized that our initial birth rate was high; therefore, we wanted to investigate the effect of altering this rate on the outcome of the disease model. In Figure 6 we assigned $\pi = 0.1$, 1 and 10. The black line represents $\pi = 10$, the blue line $\pi = 1$ and the red line $\pi = 0.1$.

Knowing that Bieber Fever would take over a population if it were introduced through the media, we altered the parameters associated with the media terms.

First, we varied the amount of negative and positive media events (N and P). The original simulation we ran had more positive than negative media events a month (two positive versus one negative), therefore we also tried switching it, such that there were more negative media events than positive (two negative versus one-half positive media events per month). The results of both simulations are shown Figure 7. In both figures, the blue line represents the susceptible population, red the infected and green the recovered.

The second parameter we altered was the proportion of media exposure (ε) while keeping the values assigned to N and P the same as our initial conditions. The initial simulation was run with the greater proportion of media being positive ($\varepsilon = 0.75$). Therefore, as illustrated in Figure 8, we assigned ε the values 0 (A), 0.25 (B) and 0.5 (C). The coloured lines represent the same populations as Figure 7.

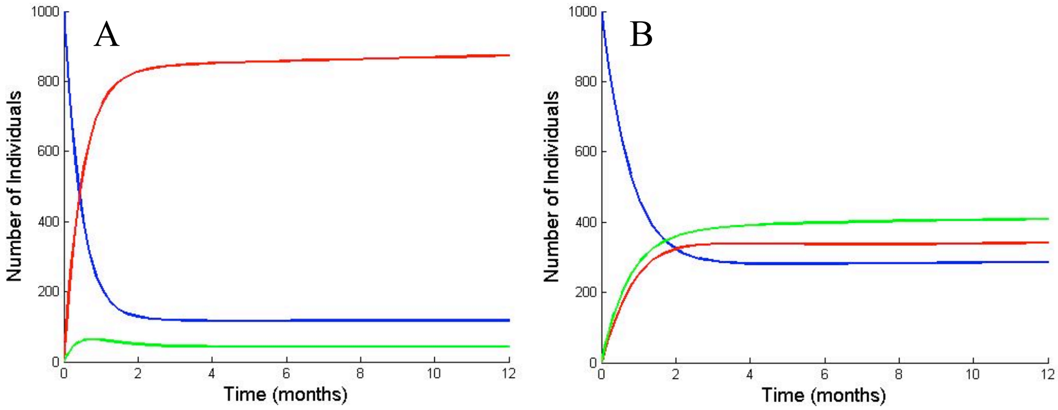
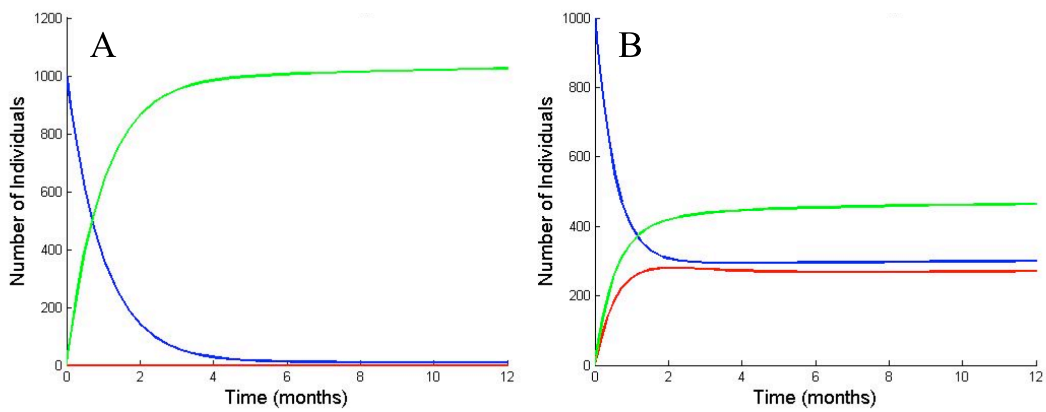


Figure 7. Bieber Fever model results for all population with the amount of positive and negative media events altered. In panel A, N=1 and P=2 and in panel B N=2 and P=0.5. The blue line represents the susceptible population, red the infected and green the recovered in both panels.



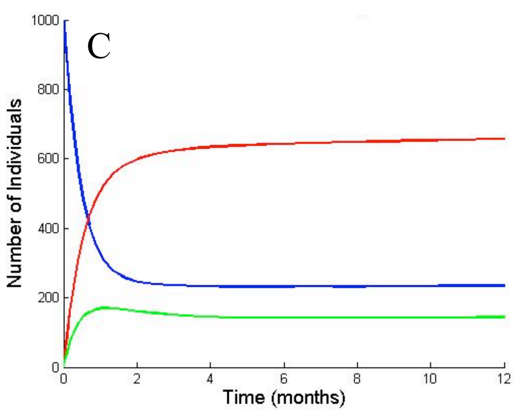


Figure 8. Bieber Fever model results for all populations when the proportion of positive versus negative media (ε) is altered. Panel A shows $\varepsilon = 0$ (all negative media), B $\varepsilon = 0.25$ (3/4 negative media) and C $\varepsilon = 0.5$ (1/2 negative media). The blue line represents the susceptible population, the red the infected population and the green the recovered population.

Discussion

From our initial simulation, we can see that the disease spreads very quickly through the population. Most of the infection occurs within the first two months of exposure and the population of infected individuals continues to increase gradually after that. This is frightening, especially when we consider no individuals started in the infected class. Even when the initial infected population is greater than zero (Figure 5) the maximum number of infected individuals does not change, the infection just occurs more rapidly.

Since we were worried the birth rate assigned was too high we re-ran the model while varying the birth rate. This did decrease the overall infected population size over time (Figure 6); however, the initial peak in number of infected individuals remained the same. Since we noted a decrease in infected population size over one year, we also tried running the model for two years, the results are shown in Figure 9. We do see a decrease in the number of infected individuals; however, the susceptible population still remains relatively stable. The accuracy of our results over this period of time becomes an issue. This is because we are assuming the proportion of exposure and the number of media events is stable across time. However, in reality, this fluctuates greatly, so it is difficult to project that far into the future.

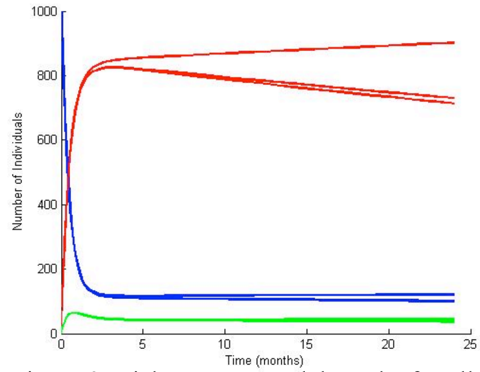


Figure 9. Bieber Fever model results for all populations when the model is run for 2 years with the values for π altered as well. The values assigned to π were 10, 1 and 0.1. The blue line represents the susceptible population, red the infected and green the recovered.

Due to the effect of media, this disease spreads very quickly. Therefore, the only way to alter the projected number of individuals in the infected population is by changing the parameters related to media. First, we altered the number of positive and negative media events. From Figure 7 we can see that so long as the number of positive media events exceeds the number of negative events, the number of infected individuals always exceeds the number of susceptible individuals. Even when the number of positive and negative media events is equal (data not shown), the number of infected individuals is also higher. Therefore, to decrease the percentage of the population infected, we need to have more negative than positive events occurring.

The other way we could alter the number of infected individuals was to change the proportion of positive versus negative media exposure. From Figure 8 we see that so long as we increase the proportion of negative media exposure so that it occurs at least ¾ of the time, then the number of infected individuals will be less than the number of susceptible individuals.

Conclusions

Our results show that in any population of young females exposed to Justin Bieber, there will be an outbreak of Bieber Fever, even if no one is initially infected. This makes the disease very dangerous and any population extremely susceptible. The only methods to help control the spread of infection are to publish more negative media stories about him than positive, such as involving him in a sex scandal or exploit his bad hair cut choices and increasing the number of times those negative stories appear in the media. These measures may seem extreme, but they will need to be weighed against the possibility of our youth driving the general public mad with their outrageous obsession with Justin Bieber.

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